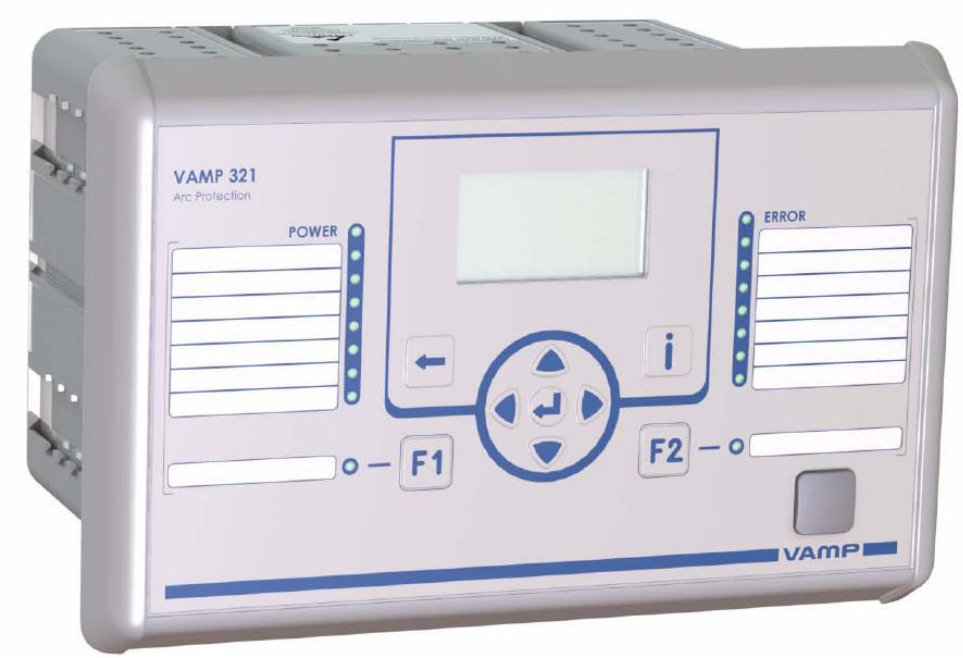
VAMP 321

Arc Flash Protection System

User manual



Legal notice

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Disclaimer

No responsibility is assumed by Vamp Ltd. for any consequences arising out of the use of this document. This document is not intended as an instruction manual for untrained persons. This document gives instructions on device installation, commissioning and operation. However, the manual cannot cover all conceivable circumstances or include detailed information on all topics. In the event of questions or specific problems, do not take any action without proper authorization. Contact Vamp Ltd. and request the necessary information.

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Safety information

⚠ DANGER

- Failure to follow these instructions will result in death or serious injury.

⚠ WARNING

- Only qualified personnel should install this equipment. Such work should be performed only after reading this entire set of instructions.
- Turn off all power supplying this equipment before starting the installation work.
- Ensure the protective grounding is connected.
- Before performing visual inspections, commissioning, or maintenance on this equipment, disconnect all sources of electric power.
- Assume that all circuits are live until they have been completely de-energised, tested and tagged. Pay particular attention to the design of the power system. Consider all sources of power, including the possibility of backfeeding.
- Beware of potential hazards, wear personal protective equipment, carefully inspect the work area for tools and objects that may have been used during commissioning or maintenance.
- Neglecting fundamental installation requirements can lead to personal injury as well as damage to electrical equipment or other property.
- Handling this equipment requires relevant expertise in the field of protection of electrical networks. Only competent people who have this expertise are allowed to configure and set up this equipment.

⚠ CAUTION

- Before performing dielectric (Hi-Pot) testing on any equipment in which the IED is installed, disconnect all input and output wires to the IED. High voltage testing can damage electronic components contained in the unit.

NOTICE

- Always use a properly rated voltage sensing device to confirm that all power is off.
- The successful operation of this equipment depends upon proper handling, installation, and operation.

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1. This document

1.1. Purpose

This document contains instructions on the installation, commissioning and operation of the VAMP 321 arc flash protection IED. This guide also contains an application example of configuring an arc flash protection system.

This document is intended for persons who are experts on electrical power engineering.

This document covers the device models as described by the ordering code in chapter "Order information" close to the end of the manual.

1.2. Related documents

Document	Identification*)
VAMP Mounting and Commissioning Instructions	VMMCARCxxx
VAMP Arc I/O units Operation and Configuration Instructions Technical Description	VMVAM.ENxxx
VAMP Arc Flash Protection Testing Manual	VMARCTEST.ENxxx
VAMPSET Setting and Configuration Tool User Manual	VMV.ENxxx

**) xxx = a three-digit document revision number*

NOTICE Download the latest documents and software at www.vamp.fi.

1.3. Symbols and conventions

1.3.1. Symbols

Symbol	Description
⚠ DANGER	Indicates a hazardous situation which, if not avoided, will result in death or serious injury.
⚠ WARNING	Indicates a hazardous situation which, if not avoided, could result in death or serious injury.
⚠ CAUTION	Indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.
NOTICE	Addresses practices not related to personal injury.

1.3.2. Conventions

Convention	Example
Menu names are presented in **bold**.	Open the **File** menu.
Buttons in software are presented in **bold**.	Click **OK**.
Parameter names are presented in *Italics*.	Select the *Stage enabled* parameter.
Parameter values are presented in *Italics*.	The parameter value is *Off*.
Push-buttons on local HMI are presented by icons.	To enter the menu, press .

2. Introduction

2.1. VAMP 321

The VAMP 321 IED includes all the arc flash protection functions, such as overcurrent and arc supervision. VAMP 321 has a modular design, and it is optimised for use in mid- and high-end arc protection systems. It can be used in various arc protection applications in low or medium voltage power distribution systems.

- Three-phase current
- Zero-sequence current
- One voltage channel for measurements and supporting functions
- Event logs, disturbance recording and real-time clock
- Operation on simultaneous current and light or on light only
- Informative LCD
- Up to 12 normally-open fast trip contacts
- Two change-over alarm contacts including IF
- Less than 7 ms operation time with a mechanical output relay, with optional IGBT card operation time is less than 1ms
- Programmable operation zones
- Continuous system self-supervision

The VAMP 321 is intended to be used as the main unit of an arc protection system, which includes also arc protection I/O units like VAM 10L and arc light sensors. The arc light sensors may be connected to the I/O units or to the main unit.

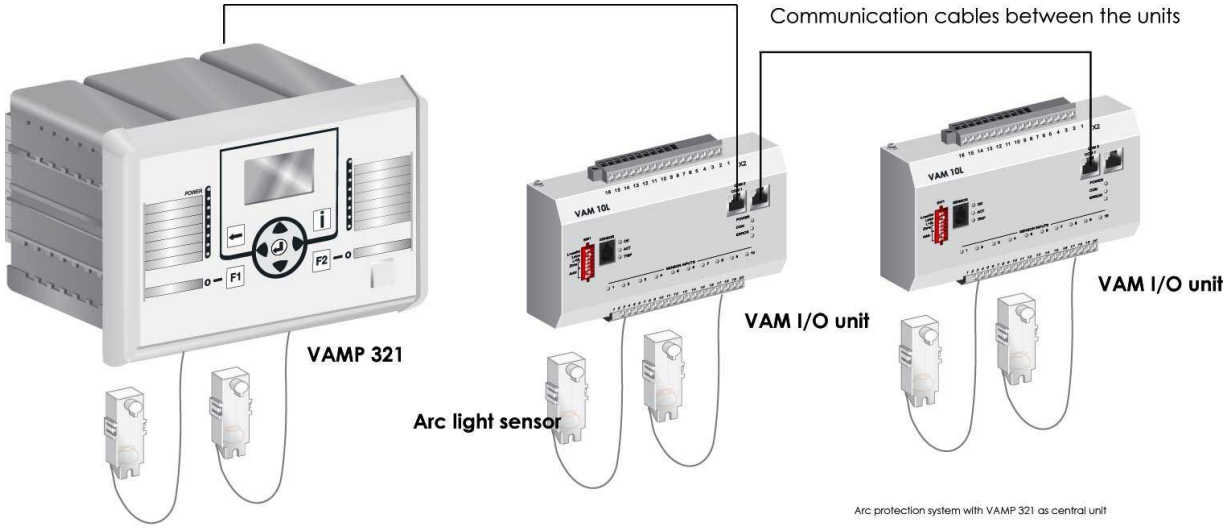

Communication cables between the units
VAMP 321
VAM I/O unit
VAM I/O unit
Arc light sensor
Arc protection system with VAMP 321 as central unit

Figure 2.1-1 Arc protection system with VAMP 321 as central unit.

2.2. Local HMI

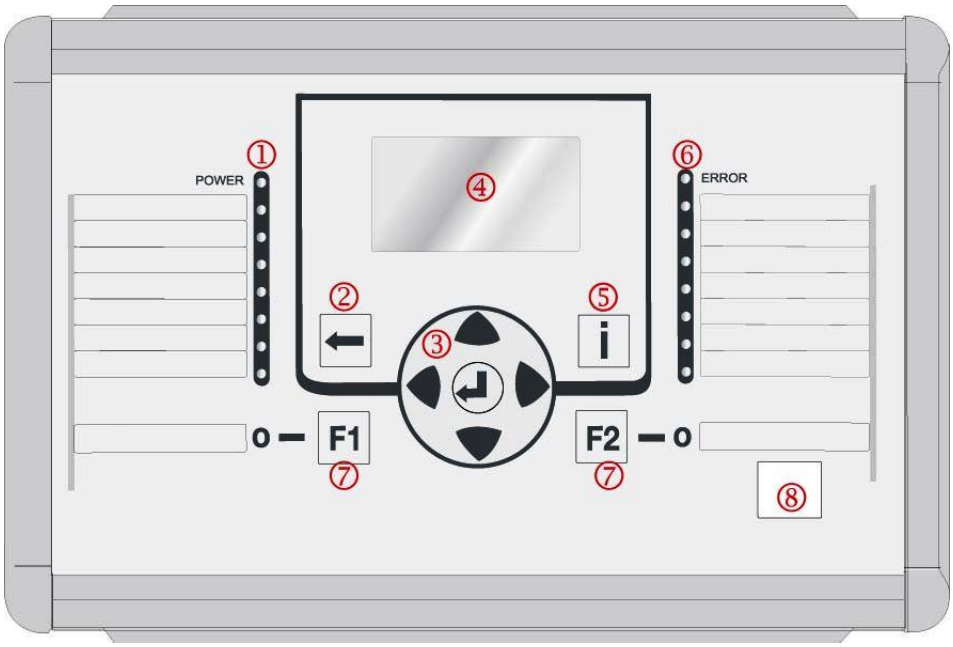


Figure 2.2-1 VAMP 321 local HMI

1 Power LED and seven programmable LEDs
2 CANCEL push-button
3 Navigation push-buttons
4 LCD
5 INFO push-button
6 Error LED and seven programmable LEDs
7 Function push-buttons and LEDs showing their status
8 Local port

Push-buttons

Symbol	Function
	CANCEL push-button for returning to the previous menu. To return to the first menu item in the main menu, press the button for at least three seconds.
	INFO push-button for viewing additional information, for entering the password view and for adjusting the LCD contrast.
	Programmable function push-button.
	Programmable function push-button.
	ENTER push-button for activating or confirming a function.
	UP navigation push-button for moving up in the menu or increasing a numerical value.
	DOWN navigation push-button for moving down in the menu or decreasing a numerical value.
	LEFT navigation push-button for moving backwards in a parallel menu or selecting a digit in a numerical value.
	RIGHT navigation push-button for moving forwards in a parallel menu or selecting a digit in a numerical value.

LEDs

The LEDs on the local HMI can be configured in VAMPSET. To customise the LED texts on the local HMI, the texts can be written on a template and then printed on a transparency. The transparencies can be placed to the pockets beside the LEDs.

Adjusting LCD contrast

1. On the local HMI, push and
2. Enter the four-digit password and push .
3. Push and adjust the contrast.
   - To increase the contrast, push .
   - To decrease the contrast, push .
4. To return to the main menu, push .

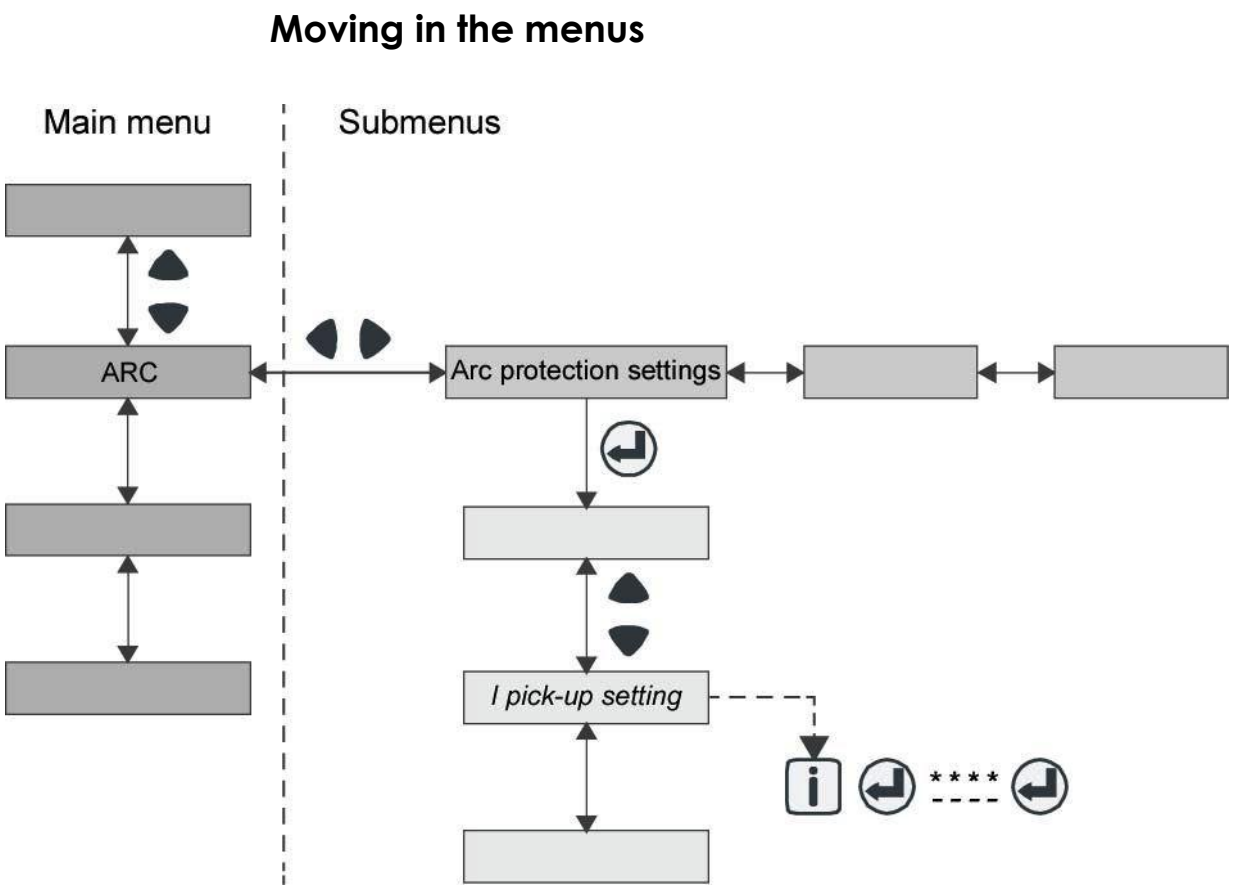


Figure 2.2-2 Moving in menus using local HMI

- To move in the main menu, push or .
- To move in submenus, push or .
- To enter a submenu, push and use or for moving down or up in the menu.
- To edit a parameter value, push and .

  Give the four-digit password and push .
- To go back to the previous menu, push .
- To go back to the first menu item in the main menu, push for at least three seconds.

NOTICE To enter the parameter edit mode, give the password. When the value is in edit mode, its background is dark.

2.3. VAMPSET setting and configuration tool

VAMPSET is a software tool for setting and configuring the Vamp IEDs. VAMPSET has a graphical interface, and the created documents can be saved and printed out for later use.

To use VAMPSET, you need

- PC with Windows XP (or newer) operating system installed
- VX052 or equivalent USB cable for connecting the IED to the PC
- Experience in using the Windows operating system
- USB drivers installed

NOTICE Download the latest VAMPSET version at www.vamp.fi.

2.4. Configuring the system with VAMPSET

Before configuring the arc flash protection system, you need

- PC with adequate user rights
- VAMPSET setting and configuration tool downloaded to the PC
- USB cable (VX052) for connecting the IED with the PC
- USB drivers installed

2.4.1. Setting up the communication

NOTICE If several IEDs are connected to a communication bus, set only one to master mode and the others to slave mode.

- Connect the USB cable between the PC and the local port of the IED.

Defining the PC serial port settings

NOTICE Ensure that the communication port setting on the PC corresponds to the IED setting.

1. Open the **Device Manager** on the PC and check the USB Serial Port number (COM) for the IED.
2. Open the VAMPSET setting and configuration tool on the PC.
3. On the VAMPSET **Settings** menu, select **Communication Settings**.
4. Select the correct port under the **Port** area and click **Apply**.

Defining the VAMPSET communication settings

1. On the local HMI, go to the **CONF/ DEVICE SETUP** menu and check the local port bit rate.
2. On the VAMPSET **Settings** menu, select **Communication Settings**.
3. Under the **Local** area, select the corresponding speed (bps) from the drop-down list and click **Apply**.
4. In VAMPSET **Settings** menu, select **Program Settings**.

NOTICE If faster operation is needed, change the speed to 187500 bps both in VAMPSET and in the IED.

Connecting the IED

1. On the VAMPSET **Communication** menu, select **Connect Device**.
2. Enter the password and click **Apply**.
   VAMPSET connects to the IED.

NOTICE The default password for the configurator is *2*.

2.4.2. Writing the settings to the IED

- In the VAMPSET **Communication** menu, select **Write All Settings To Device** to download the configuration to the IED.

NOTICE To save the IED configuration information for later use, also save the VAMPSET document file on the PC.

2.4.3. Saving the VAMPSET document file

Save the IED configuration information to the PC. The document file is helpful for instance if you need help in troubleshooting.

1. Connect the IED to the PC with an USB cable.
2. Open the VAMPSET tool on the PC.
3. On the **Communication** menu, select **Connect device**.
4. Enter the configurator password.
   The IED configuration opens.
5. On the **File** menu, click **Save as**.
6. Type a descriptive file name, select the location for the file and click **Save**.

NOTICE By default, the configuration file is saved in the VAMPSET folder.

2.5. Connecting the supply voltage

⚠WARNING Do not connect the supply voltage before the device connections and I/O unit configuration is done. If the settings need to be changed, disconnect the supply voltage before configuring the devices.

- Ensure the device connections and I/O unit configurations are in order.
- Connect the auxiliary supply voltage to the IED's terminal block.

2.6. Periodic testing

We recommend that the functionality testing of our products shall be done at least every five year interval or according to the law of the country where the relay is installed. It is proposed that the periodic testing is conducted with a secondary injection principle for those protection stages which are used in the VAMP products.

3. Protection functions

3.1. Arc flash protection

3.1.1. Arc flash protection, general principle

The arc flash protection contains 8 arc stages, which may be used to trip e.g. the circuit breakers. Arc stages are activated with overcurrent and light signals (or light signal alone). The allocation of different current and light signals to arc stages is defined in arc flash protection matrices: current, light and output matrix. The matrices are programmed via the arc flash protection menus.

3.1.2. Arc flash protection menus

The arc flash protection menus are located in the main menu under ARC. The ARC menu can be viewed either on the local HMI, or by using VAMPSET.

ARC PROTECTION

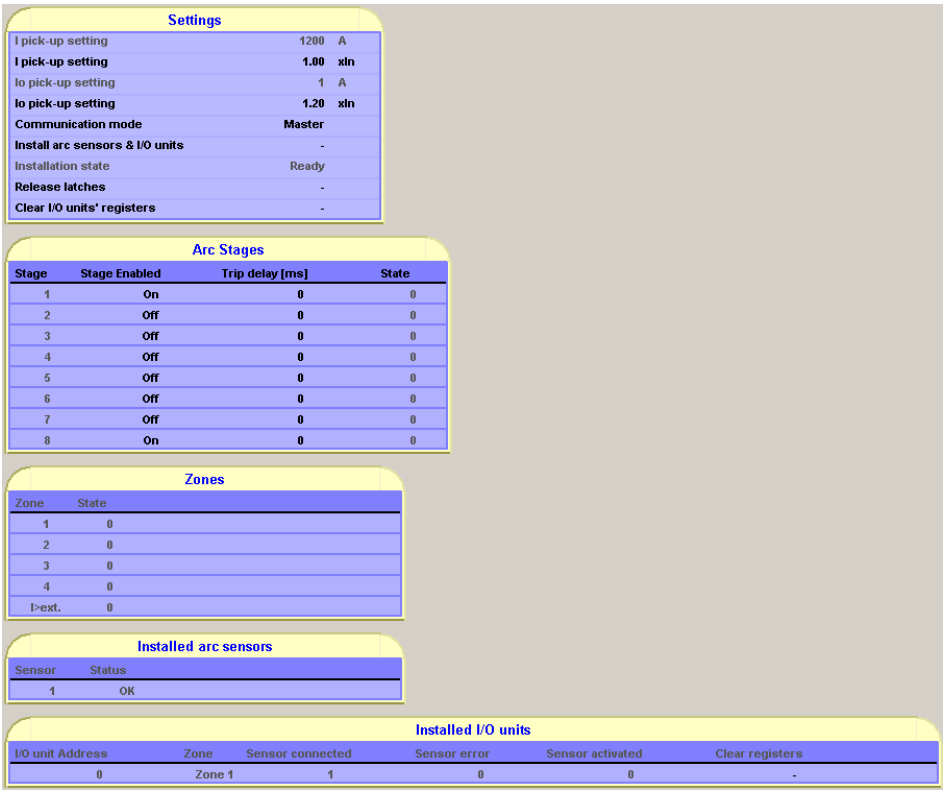


Figure 3.1.2-1 ARC PROTECTION menu

ARC PROTECTION parameter group

Item	Default	Range	Description
I pick-up setting	1.20 xIn	0.50... 8.00 xIn	Phase L1, L2, L3 overcurrent pick-up level
Io pick-up setting	1.20 xIn	0.10... 5.00 xIn	Residual overcurrent pick-up level
Communication mode	Master	Slave, Master	Arc I/O communication mode
Install arc sensors & I/O units	-	-, Install	Installs all connected I/O units and sensors
Installation state	Ready	Installing, Ready	Installation state
Release latches	-	-, Release	Releases latches from the IED
Clear I/O unit's registers	-	-, Clear	Clears the I/O unit indications and latches
Stage Enabled	On or Off	On, Off	Enables the Arc protection stage
Trip delay [ms]	0	0...255	Trip delay for the Arc protection stage

NOTICE Use trip delay for separate arc stage as breaker failure protection (CBFP).

ARC MATRIX – CURRENT

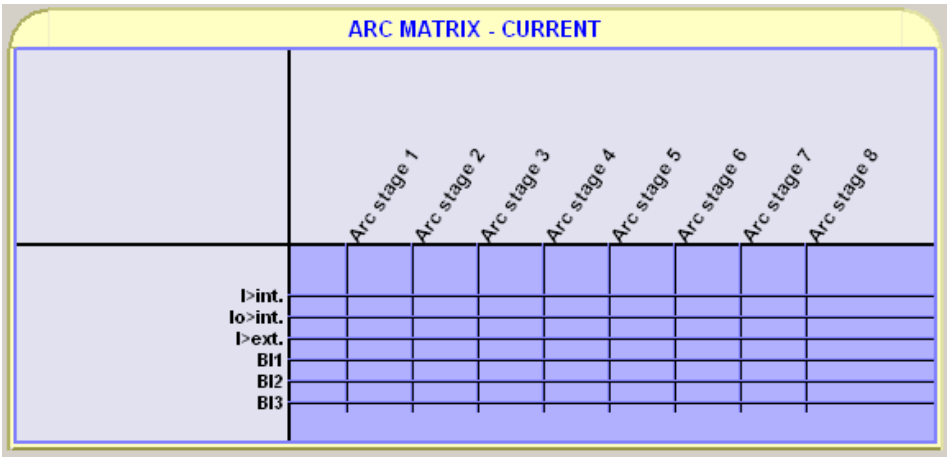


Figure 3.1.2-2 ARC MATRIX - CURRENT menu

In the ARC MATRIX - CURRENT setting view available current signals (left column) are linked to the appropriate Arc stages (1…8).

ARC MATRIX – CURRENT parameter group

Item	Default	Range	Description
I>int.	-	On, Off	Phase L1, L2, L3 overcurrent signal
Io>int.	-	On, Off	Residual overcurrent signal
I>ext.	-	On, Off	External overcurrent signal
BI1...BI3	-	On, Off	Binary input 1...3 signal
Arc stage 1...8	-	On, Off	Arc protection stage 1...8

ARC MATRIX – LIGHT

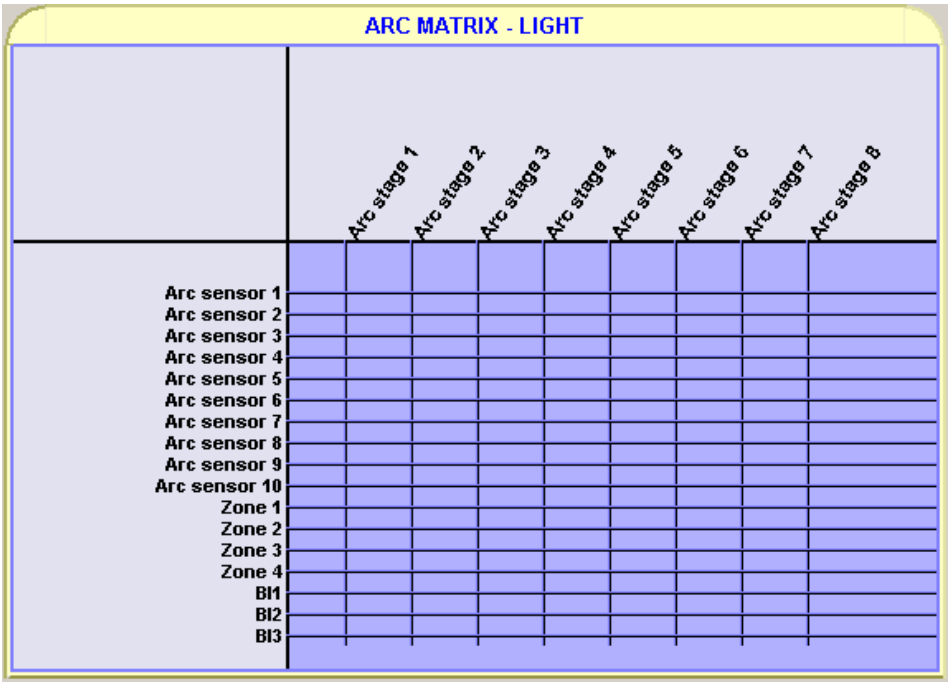


Figure 3.1.2-3 ARC MATRIX - LIGHT menu

In the ARC MATRIX - LIGHT setting view available arc light signals are linked (left column) are linked to the appropriate Arc stages (1…8).

ARC MATRIX – LIGHT parameter group

Item	Default	Range	Description
Arc sensor 1...10	-	On, Off	Internal arc flash sensor 1...10
Zone 1...4	-	On, Off	Arc light zone 1...4
BI1...3	-	On, Off	Binary input 1...3 signal
Arc stage 1...7	-	On, Off	Arc protection stage 1...7

ARC MATRIX – OUTPUT

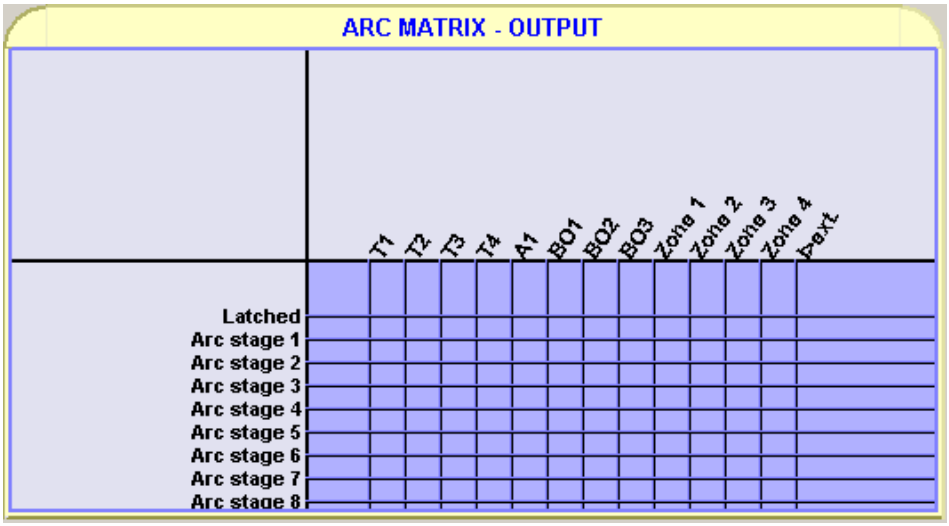


Figure 3.1.2-4 ARC MATRIX - OUTPUT menu

In the ARC MATRIX - OUTPUT setting view the used Arc stages (1…8) are connected to the required outputs. Possible latched function per output is also determined in this view.

ARC MATRIX – OUTPUT parameter group

Item	Default	Range	Description
Latched	-	On, Off	Output latch
Arc stage 1...8	-	On, Off	Arc protection stage 1...8
T1...4	-	On, Off	Trip output relay 1...4
A1	-	On, Off	Alarm relay 1
BO1...3	-	On, Off	Binary output 1...3
Zone 1...4	-	On, Off	Arc light zone 1...4
I>ext.	-	On, Off	External overcurrent signal

Matrix correlation principle

When determining the activating conditions for a certain arc stage, a logical AND is made between the outputs from the arc light matrix and arc current matrix.

If an arc stage has selections in only one of the matrixes, the stage operates on light-only or on current-only principle.

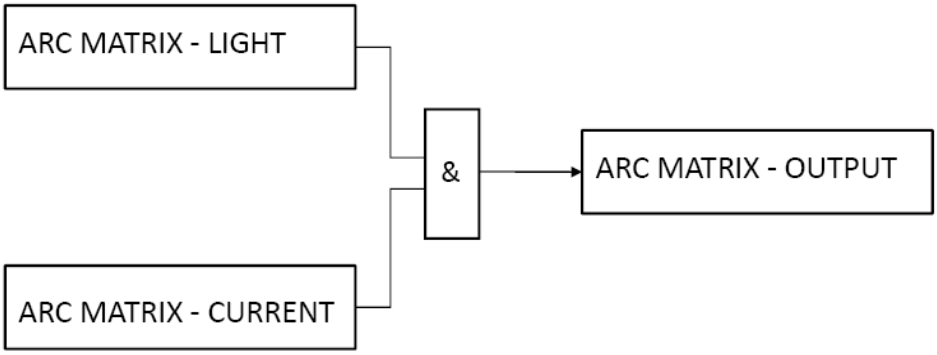


Figure 3.1.2-5 Matrix correlation principle with the logical AND operator

ARC EVENT ENABLING

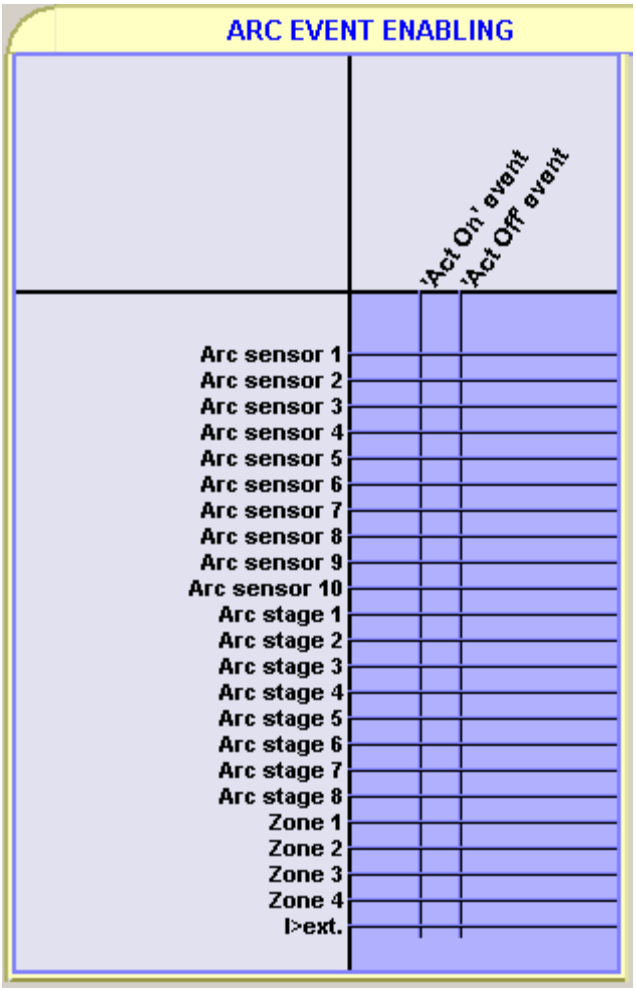


Figure 3.1.2-6 ARC EVENT ENABLING menu

ARC EVENT ENABLING parameter group

Item	Default	Range	Description
Arc sensor 1...10	-	On, Off	Arc flash sensor 1...10
Arc stage 1...8	-	On, Off	Arc protection stage 1...8
Zone 1...4	-	On, Off	Arc light zone 1...4
I>ext.	-	On, Off	External overcurrent signal
'Act On' event	-	On, Off	Event enabling
'Act Off" event	-	On, Off	Event enabling

3.1.3. Configuring the arc flash protection

Installing the arc flash sensors and I/O units

1. On the VAMPSET group list, select **ARC PROTECTION**.
2. Under **Settings**, click the **Install arc sensors & I/O units** drop-down list and select **Install**.
3. Wait until the **Installation state** shows **Ready**. The communication between the system components is created.

The installed sensors and units can be viewed at the bottom of the **ARC PROTECTION** group view.

Configuring the current pick-up values

The **SCALING** menu contains the primary and secondary values of the CT. However, the **ARC PROTECTION** menu calculates the primary value only after the **I pick-up setting** value is given.

For example:

1. On the VAMPSET group list, select **SCALING**.
2. Click the **CT primary** value, set it to e.g. *1200 A* and press **Enter**.
3. Click the **CT secondary** value, set it to e.g. *5 A* and press **Enter**.
4. On the VAMPSET group list, select **ARC PROTECTION**
5. Define the **I pick-up setting** value for the IED. Now the primary value is calculated.
6. Define the Io pick-up setting in similar manner.

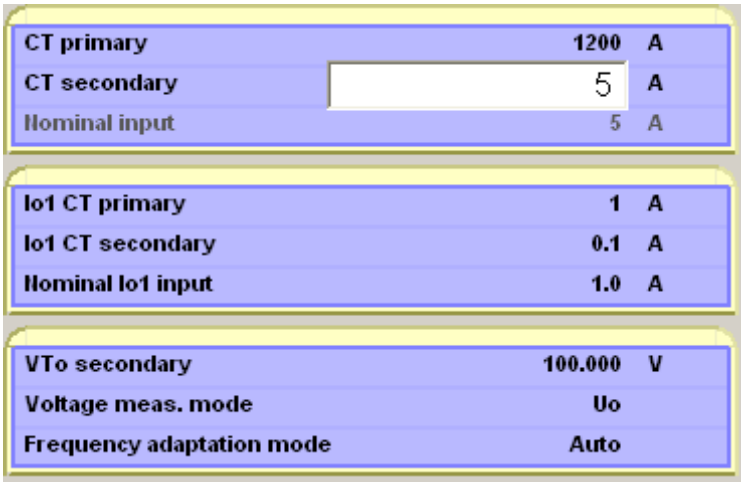

CT primary 1200 A
CT secondary 5 A
Nominal input 5 A
Io1 CT primary 1 A
Io1 CT secondary 0.1 A
Nominal Io1 input 1.0 A
VTo secondary 100.000 V
Voltage meas. mode Uo
Frequency adaptation mode Auto

Figure 3.1.3-1 Setting the current transformer scaling values.

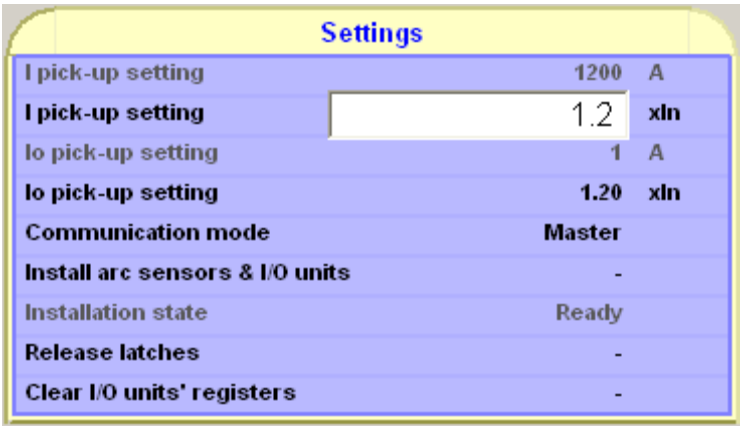

Settings
I pick-up setting 1200 A
I pick-up setting 1.2 xIn
Io pick-up setting 1 A
Io pick-up setting 1.20 xIn
Communication mode Master
Install arc sensors & I/O units -
Installation state Ready
Release latches -
Clear I/O units' registers -

Figure 3.1.3-2 Defining the I pick-up setting value.

Configuring the current matrix

Define the current signals that are received in the arc flash protection system's IED. Connect currents to Arc stages in the matrix.

For example:

The arc flash fault current is measured from the incoming feeder, and the current signal is linked to **Arc stage 1** in the current matrix.

1. On the VAMPSET group list, select **ARC MATRIX – CURRENT**.
2. In the matrix, select the connection point of **Arc stage 1** and **I>int**.
3. On the **Communication** menu, select **Write Changed Settings To Device.**

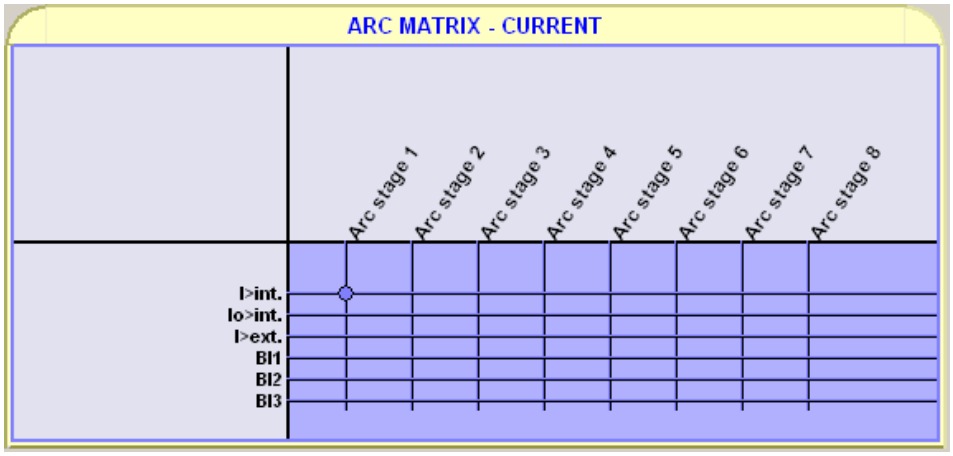


Figure 3.1.3-3 Configuring the current matrix – an example

Configuring the light matrix

Define what light sensor signals are received in the protection system. Connect light signals to arc stages in the matrix.

For example:

1. On the VAMPSET group list, select **ARC MATRIX – LIGHT**.
2. In the matrix, select the connection point of **Arc sensor 1** and **Arc stage 2**.
3. Select the connection point of **Arc sensor 2** and **Arc stage 2**.
4. Select the connection point of **Zone 1** and **Arc stage 1**.
5. On the **Communication** menu, select **Write Changed Settings To Device.**

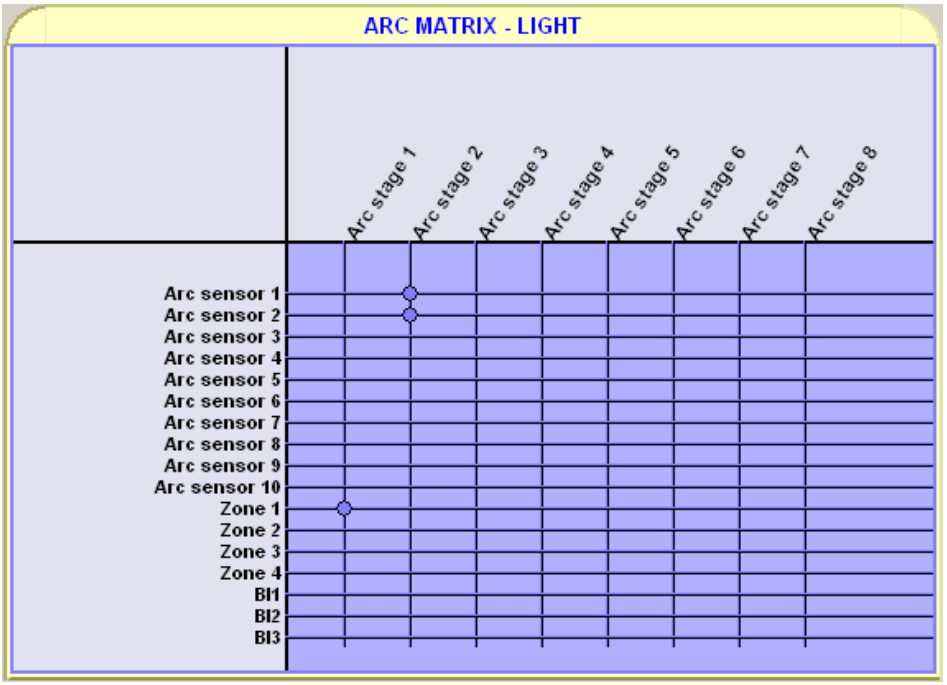


Figure 3.1.3-4 Configuring the arc matrix for – an example

Configuring the output matrix

Define the trip relays to which the current and light signals have effect.

For example:

1. On the VAMPSET group list, select **ARC MATRIX – OUTPUT**.
2. In the matrix, select the connection point of **Arc stage 1** and **T1**.
3. Select the connection points of **Latched** and **T1** and **T2**.
4. Select the connection point of **Arc stage 2** and **T2**.
5. On the **Communication** menu, select **Write Changed Settings To Device.**

NOTICE It is recommended to use latched outputs for the trip outputs.

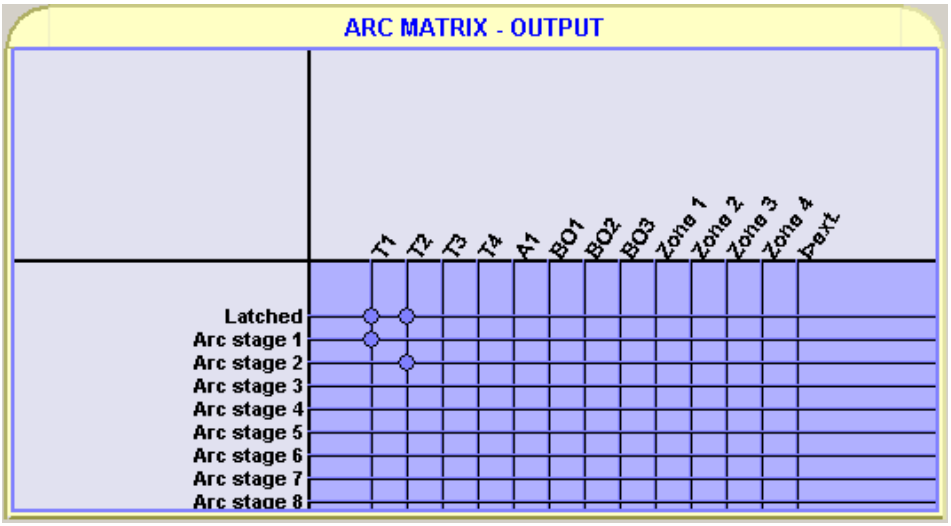


Figure 3.1.3-5 Configuring the output matrix - an example

Configuring the arc events

Define which arc events are written to the event list in this application.

For example:

1. On the VAMPSET group list, select **ARC EVENT ENABLING**.
2. In the matrix, enable both **'Act On' event** and **'Act Off" event** for **Arc sensor 1**, **Arc stage 1**, **Arc stage 2** and **Zone 1**.
3. On the **Communication** menu, select **Write Changed Settings To Device.**

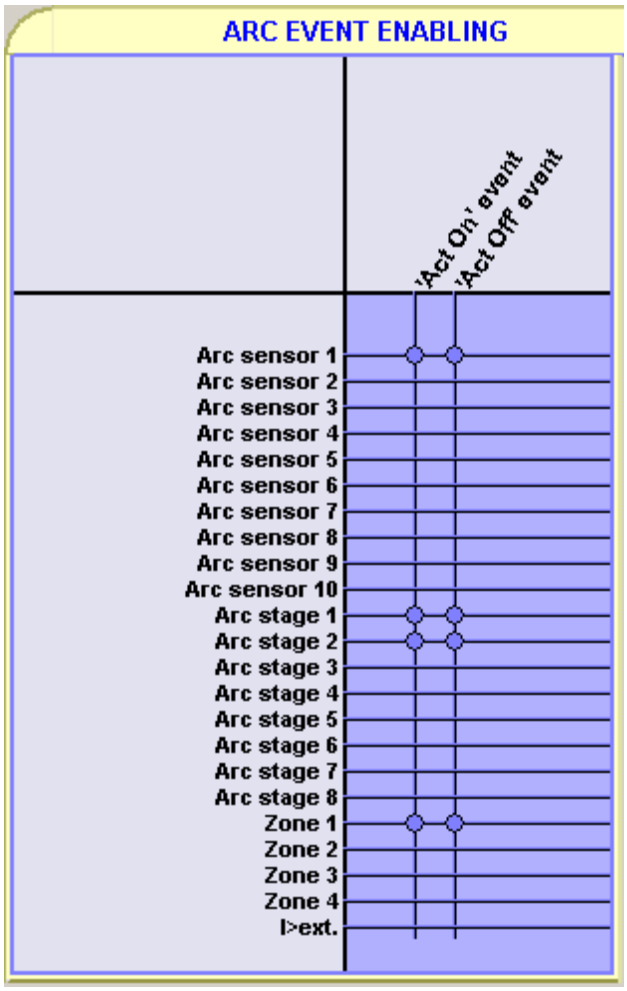


Figure 3.1.3-6 Configuring the arc events – an example

Configuring the LED names

1. On the VAMPSET group list, select **LED NAMES**.
2. To change a LED name, click the LED **Description** text and type a new name. Press **Enter**.

LED	Description	LED	Description
LED A (green)	LED A (green)	LED B (green)	LED B (green)
LED A (red)	LED A (red)	LED B (red)	LED B (red)
LED C (green)	LED C (green)	LED D (green)	LED D (green)
LED C (red)	LED C (red)	LED D (red)	LED D (red)
LED E (green)	LED E (green)	LED F (green)	LED F (green)
LED E (red)	LED E (red)	LED F (red)	LED F (red)
LED G (green)	LED G (green)	LED H (green)	LED H (green)
LED G (red)	LED G (red)	LED H (red)	LED H (red)
LED I (green)	LED I (green)	LED J (green)	LED J (green)
LED I (red)	LED I (red)	LED J (red)	LED J (red)
LED K (green)	LED K (green)	LED L (green)	LED L (green)
LED K (red)	LED K (red)	LED L (red)	LED L (red)
LED M (green)	LED M (green)	LED N (green)	LED N (green)
LED M (red)	LED M (red)	LED N (red)	LED N (red)

Figure 3.1.3-7 LED NAMES menu in VAMPSET for LED configuration

3.1.4. Related VAM I/O units

NOTICE For more information on I/O units, such as panel and programming switch descriptions, see the separate documentation.

VAM I/O units

I/O unit	Description
VAM 4C VAM 4CD	Current I/O unit serving as a link between the system's current inputs and the IED. Each I/O unit has connections for three current transformers and one trip output.
VAM 3L VAM 3LX	Fibre sensor I/O unit serving as a link between the system's fibre sensors and the IED. Each I/O unit has connections for three arc sensors, one pin sensor and one trip output.
VAM 10L VAM 10LD	Point sensor I/O unit serving as a link between the system's point sensors and the IED. Each I/O unit has connections for ten arc sensors, one portable pin sensor and one trip output.
VAM 12L VAM 12LD	Point sensor I/O unit serving as a link between the system's point sensors and the IED. Each I/O unit has connections for ten arc sensors, one portable pin sensor and three trip outputs.

3.2. Programmable stages (99)

For special applications the user can built his own protection stages by selecting the supervised signal and the comparison mode.

The following parameters are available:

- **Priority**

  If operation times less than 60 milliseconds are needed select 10 ms. For operation times under one second a 20 ms setting is recommended. For longer operation times and THD signals 100 ms is recommended.

- **Link**

  The name of the supervised signal (see table below).

- **Cmp**

  Compare mode. '>' for over or '<' for under comparison.

- **Pick-up**

  Limit of the stage. The available setting range and the unit depend on the selected signal.

- **T**

  Definite time operation delay

- **Hyster**

  Dead band (hysteresis)

- **NoCmp**

  Only used with compare mode under ('<'). This is the limit to start the comparison. Signal values under NoCmp are not regarded as fault.

Table 3.2-1Available signals to be supervised by the programmable stages

IL1, IL2, IL3	Phase currents
Io	Residual current input I_0
U12, U23, U31	Line-to-line voltages
UL1, UL2, UL3	Phase-to-ground voltages
Uo	Zero-sequence voltage
F	Frequency
IoCalc	Phasor sum $\underline{I}_{L1} + \underline{I}_{L2} + \underline{I}_{L3}$
I1	Positive sequence current
I2	Negative sequence current
I2/I1	Relative negative sequence current
I2/In	Negative sequence current in pu
U1	Positive sequence voltage
U2	Negative sequence voltage
U2/U1	Relative negative sequence voltage
IL	Average $(I_{L1} + I_{L2} + I_{L3})/3$
Uphase	Average of UL1, UL2, UL3
Uline	Average of U12, U23, U32
THDIL1	Total harmonic distortion of I_{L1}
THDIL2	Total harmonic distortion of I_{L2}
THDIL3	Total harmonic distortion of I_{L3}
THDUa	Total harmonic distortion of input U_a
IL1rms	IL1 RMS for average sampling
IL2rms	IL2 RMS for average sampling
IL3rms	IL3 RMS for average sampling
ILmin	Minimum of IL1, IL2, IL3
ILmax	Maximum of IL1, IL2, IL3
ULLmin	Maximum of U12, U23, U32
ULLmax	Average of U12, U23, U32
ULNmin	Minimum of UL1, UL2, UL3
ULNmax	Maximum of UL1, UL2, UL3
Ucomm	Common mode voltage of Uo input
Io1rms	RMS current of input Io

NOTICE The availability of voltage measurements depends on the selected voltage measurement mode of the device.

Eight independent stages

The device has eight independent programmable stages. Each programmable stage can be enabled or disabled to fit the intended application.

Setting groups

There are two settings groups available. Switching between setting groups can be controlled by digital inputs, virtual inputs (communication, logic) and manually.

There are two identical stages available with independent setting parameters.

Parameters of the programmable stages PrgN (99)

Parameter	Value	Unit	Description	Note
Status	- Blocked Start Trip		Current status of the stage	 F F
SCntr			Cumulative start counter	C
TCntr			Cumulative trip counter	C
SetGrp	1 or 2		Active setting group	Set
SGrpDI	 - DIx VIx LEDx VOx Fx		Digital signal to select the active setting group None Digital input Virtual input LED indicator signal Virtual output Function key	Set
Force	Off On		Force flag for status forcing for test purposes. This is a common flag for all stages and output relays, too. Automatically reset by a 5-minute timeout.	Set
Link	(See Table 3.2-1)		Name for the supervised signal	Set
(See Table 3.2-1)			Value of the supervised signal	
Cmp	 > <		Mode of comparison Over protection Under protection	Set
Pickup			Pick up value scaled to primary level	
Pickup		pu	Pick up setting in pu	Set
t		s	Definite operation time.	Set
Hyster		%	Dead band setting	Set
NoCmp		pu	Minimum value to start under comparison. (Mode='<')	Set

Set = An editable parameter (password needed)

C = Can be cleared to zero

F = Editable when force flag is on

Recorded values of the latest eight faults

There is detailed information available of the eight latest faults: Time stamp, fault value and elapsed delay.

Recorded values of the programmable stages PrgN (99)

Parameter	Value	Unit	Description
	yyyy-mm-dd		Time stamp of the recording, date
	hh:mm:ss.ms		Time stamp, time of day
Flt		pu	Fault value
EDly		%	Elapsed time of the operating time setting. 100% = trip
SetGrp	1 2		Active setting group during fault

4. Supporting functions

4.1. Event log

Event log is a buffer of event codes and time stamps including date and time. For example each start-on, start-off, trip-on or trip-off of any protection stage has a unique event number code. Such a code and the corresponding time stamp is called an event.

As an example of information included with a typical event a programmable stage trip event is shown in the following table.

EVENT	Description	Local panel	Communication protocols
Code: 46E2	Channel 46, event 2	Yes	Yes
Prg1 trip on	Event text	Yes	No
0,41 x In	Fault value	Yes	No
2007-01-31	Date	Yes	Yes
08:35:13.413	Time	Yes	Yes

Events are the major data for a SCADA system. SCADA systems are reading events using any of the available communication protocols. Event log can also be scanned using the front panel or using VAMPSET. With VAMSET the events can be stored to a file especially in case the relay is not connected to any SCADA system.

Only the latest event can be read when using communication protocols or VAMPSET. Every reading increments the internal read pointer to the event buffer. (In case of communication error, the latest event can be reread any number of times using an other parameter.) On the local panel scanning the event buffer back and forth is possible.

Event enabling/masking

In case of an uninteresting event, it can be masked, which prevents the particular event(s) to be written in the event buffer.

As a default there is room for 200 latest events in the buffer. Event buffer size can be modified from 50 to 2000. Modification can be done in “Local panel conf” –menu. Alarm screen (popup screen) can also be enabled in this same menu when Vampset – setting tool is used. The oldest one will be overwritten, when a new event does occur. The shown resolution of a time stamp is one millisecond, but the actual resolution depends of the

particular function creating the event. For example most protection stages create events with 10 ms or 20 ms resolution. The absolute accuracy of all time stamps depends on the time synchronizing of the relay. See chapter 4.3 for system clock synchronizing.

Event buffer overflow

The normal procedure is to poll events from the device all the time. If this is not done, the event buffer will eventually overflow. On the local screen this is indicated with string "OVF" after the event code.

Setting parameters for events

Parameter	Value	Description	Note
Count		Number of events	
ClrEn	– Clear	Clear event buffer	Set
Order	Old-New New-Old	Order of the event buffer for local display	Set
FVSca	PU Pri	Scaling of event fault value Per unit scaling Primary scaling	Set
Display Alarms	On Off	Alarm pop-up display is enabled No alarm display	Set
FORMAT OF EVENTS ON THE LOCAL DISPLAY			
Code: CHENN		CH = event channel, NN=event code	
Event description		Event channel and code in plain text	
yyyy-mm-dd		Date (for available date formats see chapter 4.3)	
hh:mm:ss.nnn		Time	

4.2. Disturbance recorder

The disturbance recorder can be used to record all the measured signals, that is, currents, voltage and the status information of digital inputs (DI) and digital outputs (DO). The digital inputs include also the arc protection signals.

Triggering the recorder

The recorder can be triggered by any start or trip signal from any protection stage or by a digital input. The triggering signal is selected in the output matrix (vertical signal DR). The recording can also be triggered manually. All recordings are time stamped.

Reading recordings

The recordings can be uploaded, viewed and analysed with the VAMPSET program. The recording is in COMTRADE format. This means that also other programs can be used to view and analyse the recordings made by the relay.

For more details, please see a separate VAMPSET manual.

Number of channels

At the maximum, there can be 12 recordings, and the maximum selection of channels in one recording is also 12 (limited in waveform recording). The digital inputs reserve one channel (includes all the inputs). Also the digital outputs reserve one channel (includes all the outputs). If digital inputs and outputs are recorded, there will be still 10 channels left for analogue waveforms.

Disturbance recorder parameters

Parameter	Value	Unit	Description	Note
Mode	 Saturated Overflow		Behaviour in memory full situation: No more recordings are accepted The oldest recorder will be overwritten	Set
SR	 32/cycle 16/cycle 8/cycle 1/10ms 1/20ms 1/200ms 1/1s 1/5s 1/10s 1/15s 1/30s 1/1min		Sample rate Waveform Waveform Waveform One cycle value One cycle value Average Average Average Average Average Average Average	Set
Time		s	Recording length	Set
PreTrig		%	Amount of recording data before the trig moment	Set
MaxLen		s	Maximum time setting. This value depends on sample rate, number and type of the selected channels and the configured recording length.	
Status	 – Run Trig FULL		Status of recording Not active Waiting a triggering Recording Memory is full in saturated mode	
ManTrig	 – Trig		Manual triggering	Set
ReadyRec	n/m		n = Available recordings m = maximum number of recordings The value of 'm' depends on sample rate, number and type of the selected channels and the configured recording length.	

Parameter	Value	Unit	Description	Note
AddCh			Add one channel. Maximum simultaneous number of channels is 12.	Set
	IL1, IL2, IL3		Phase current	
	Io1		Measured residual current	
	U12, U23, U31		Line-to-line voltage	
	UL1, UL2, UL3		Phase-to-neutral voltage	
	Uo		Zero sequence voltage	
	f		Frequency	
	IoCalc		Phasor sum Io = (IL1+IL2+IL3)/3	
	I1		Positive sequence current	
	I2		Negative sequence current	
	I2/I1		Relative current unbalance	
	I2/In		Current unbalance [xIGN]	
	U1		Positive sequence voltage	
	U2		Negateive sequence voltage	
	U2/U1		Relative negative sequence voltage	
	IL		Average (IL1 + IL2 + IL3)/3	
	Uphase		Average phase voltage	
	Uline		Average line-to-lines voltages	
	DI, DO		Digital inputs and outputs	
	THDIL1, THDUL2, THDIL3		Total harmonic distortion of IL1, IL2 or IL3	
	THDUa		Total harmonic distortion of Ua	
	IL1RMS, IL2MRS, IL3RMS		IL1, IL2, IL3 RMS for average sampling	
	ILmin, ILmax		Min and max of phase currents	
	ULLmin, ULLmax		Min and max of line-toline voltages	
	ULNmin, ULNmax		Min and max of phase voltages	
	Ucomm		Common mode voltage of Uo-input	
	Io1rms		RMS current of input Io1	
	Arc		Arc protection signals	
ClrCh	– Clear		Remove all channels	Set
(Ch)			List of selected channels	

Set = An editable parameter (password needed)

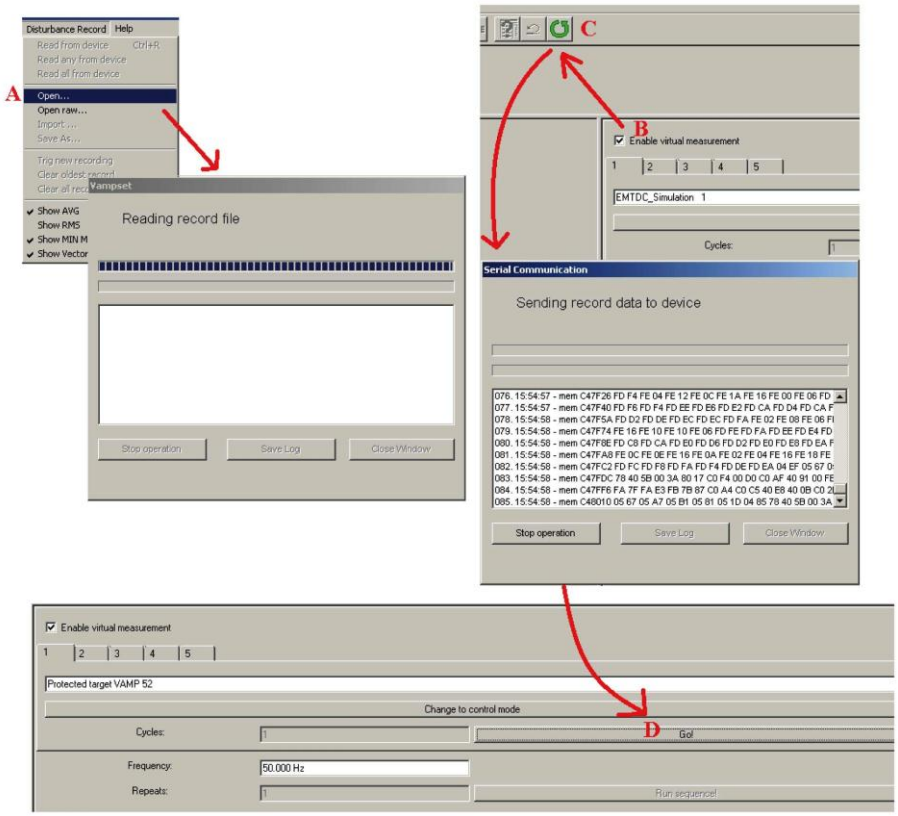
Running virtual comtrade files

Virtual comtrade files can be run with the device. Device behaviour can be analysed by playing the recorder data over and over again in the relay memory.

NOTICE This is not applicable to the arc protection functions of the device.

Steps of opening the VAMPSET setting tool.

1. Go to "Disturbance record" and select Open… (A).
2. Select the comtrade file from you hard disc or equivalent. VAMPSET is now ready to read the recording.
3. The virtual measurement has to be enabled (B) in order to send record data to the relay (C).
4. Sending the file to the device's memory takes a few seconds. Initiate playback of the file by pressing the Go! button (D). The "Change to control mode" button takes you back to the virtual measurement.



NOTICE The sample rate of the comtrade file has to be 32/cycle (625 micro seconds when 50 Hz is used). The channel names have to correspond to the channel names in Vamp relays: IL1, IL2, IL3, Io1, Io2, U12, U23, UL1, UL2, UL3 and Uo.

4.3. System clock and synchronization

The internal clock of the relay is used to time stamp events and disturbance recordings.

The system clock should be externally synchronised to get comparable event time stamps for all the relays in the system.

The synchronizing is based on the difference of the internal time and the synchronising message or pulse. This deviation is filtered and the internal time is corrected softly towards a zero deviation.

Adapting auto adjust

During tens of hours of synchronizing the device will learn its average error and starts to make small corrections by itself. The target is that when the next synchronizing message is received, the deviation is already near zero. Parameters "AAIntv" and "AvDrft" will show the adapted correction time interval of this ±1 ms auto-adjust function.

Time drift correction without external sync

If any external synchronizing source is not available and the system clock has a known steady drift, it is possible to roughly correct the clock error by editing the parameters "AAIntv" and "AvDrft". The following equation can be used if the previous "AAIntv" value has been zero.

$$AAIntv = \frac{604.8}{DriftInOneWeek}$$

If the auto-adjust interval "AAIntv" has not been zero, but further trimming is still needed, the following equation can be used to calculate a new auto-adjust interval.

$$AAIntv_{NEW} = \frac{1}{\frac{1}{AAIntv_{PREVIOUS}} + \frac{DriftInOneWeek}{604.8}}$$

The term *DriftInOneWeek*/604.8 may be replaced with the relative drift multiplied by 1000, if some other period than one week has been used. For example if the drift has been 37 seconds in 14 days, the relative drift is 37*1000/(14*24*3600) = 0.0306 ms/s.

Example 1.

If there has been no external sync and the relay's clock is leading sixty-one seconds a week and the parameter AAIntv has been zero, the parameters are set as

$$AvDrft = Lead$$

$$AAIntv = \frac{604.8}{61} = 9.9s$$

With these parameter values the system clock corrects itself with –1 ms every 9.9 seconds which equals –61.091 s/week.

Example 2.

If there is no external sync and the relay's clock has been lagging five seconds in nine days and the AAIntv has been 9.9 s, leading, then the parameters are set as

$$AAIntv_{NEW} = \frac{1}{\frac{1}{9.9} - \frac{5000}{9 \cdot 24 \cdot 3600}} = 10.6$$

$$AvDrft = Lead$$

NOTICE

When the internal time is roughly correct – deviation is less than four seconds – any synchronizing or auto-adjust will never turn the clock backwards. Instead, in case the clock is leading, it is softly slowed down to maintain causality.

System clock parameters

Parameter	Value	Unit	Description	Note
Date			Current date	Set
Time			Current time	Set
Style	 y–d–m d.m.y m/d/y		Date format Year-Month-Day Day.Month.Year Month/Day/Year	Set
SyncDI	Possible values depends on the types of I/O cards		The digital input used for clock synchronisation. DI not used for synchronizing Minute pulse input	***)
TZone	–12.00 ... +14.00 *)		UTC time zone for SNTP synchronization. Note: This is a decimal number. For example for state of Nepal the time zone 5:45 is given as 5.75	Set
DST	No Yes		Daylight saving time for SNTP	Set
SySrc	 Internal DI SNTP SpaBus ModBus ProfibusDP IEC-103 IEC101 DNP3 IRIG-B003		Clock synchronisation source No sync recognized since 200s Digital input Protocol sync Protocol sync Protocol sync Protocol sync Protocol sync Protocol sync Protocol sync IRIG timecode B003 ****)	
MsgCnt	0 ... 65535, 0 ... etc.		The number of received synchronisation messages or pulses	
Dev	±32767	ms	Latest time deviation between the system clock and the received synchronization	
SyOS	±10000.000	s	Synchronisation correction for any constant error in the synchronizing source.	Set
AAIntv	±10000	s	Adapted auto adjust interval for 1 ms correction	Set**)
AvDrft	Lead Lag		Adapted average clock drift sign	Set **)
FilDev	±125	ms	Filtered synchronisation deviation	

Set = An editable parameter (password needed).

*) Astronomically a range –11 ... +12 h would be enough, but for political and geographical reasons a larger range is needed.

**) If external synchronization is used this parameter will be set automatically.

***) Set the DI delay to its minimum and the polarity such that the leading edge is the synchronizing edge.

****) Relay needs to be equipped with an IRIG-B option module to receive clock syncronization signal (see chapter **Error! Reference source not found.** for more information).

Synchronisation with DI

Clock can be synchronized by reading minute pulses from digital inputs, virtual inputs or virtual outputs. Sync source is selected with **Minute sync pulse DI** setting. When rising edge is detected from the selected input, system clock is adjusted to the nearest minute. Length of digital input pulse should be at least 50 ms. Delay of the selected digital input should be set to zero.

Synchronisation correction

If the sync source has a known offset delay, it can be compensated with **SyOS** setting. This is useful for compensating hardware delays or transfer delays of communication protocols. A positive value will compensate a lagging external sync and communication delays. A negative value will compensate any leading offset of the external synch source.

Sync source

When the device receives new sync message, the sync source display is updated. If no new sync messages are received within next 1.5 minutes, the device will change to internal sync mode.

Deviation

The time deviation means how much system clock time differs from sync source time. Time deviation is calculated after receiving new sync message. The filtered deviation means how much the system clock was really adjusted. Filtering takes care of small errors in sync messages.

Auto-lag/lead

The device synchronizes to the sync source, meaning it starts automatically leading or lagging to stay in perfect sync with the master. The learning process takes few days.

4.4. Non-volatile RAM

The non-volatile RAM of the device is implemented using a super capacitor and a RAM memory with low power consumption.

When auxiliary power is on the super capacitor is charged from the internal power supply of the device and the non-volatile RAM memory also gets power from the same source. When auxiliary power is turned off the RAM memory is powered by the super capacitor. The memory will keep its contents as long as there is enough voltage in the super capacitor. This time is 7 days in +25C room temperature – high humidity will decrease the time.

The non-volative RAM is used to store the disturbance recordings and the event-buffer.

4.5. Self-supervision

The functions of the microcontroller and the associated circuitry, as well as the program execution are supervised by means of a separate watchdog circuit. Besides supervising the relay, the watchdog circuit attempts to restart the micro controller in a fault situation. If the restarting fails, the watchdog issues a self-supervision alarm indicating a permanent internal fault.

When the watchdog circuit detects a permanent fault, it always blocks any control of other output relays (except for the self-supervision output relay and the output relays used in the arc protection funcion).

In addition, the internal supply voltages are supervised. Should the auxiliary supply of the IED disappear, an alarm is automatically given because the internal fault (IF) output relay functions on a working current principle. This means that the IF relay is energized when the auxiliary supply is on and no internal fault is detected.

The condition of the VAMP 321 central unit, the I/O units and the sensors are supervised. Events are generated when errors occur or disappear. The events are stored in the IED event buffer and they can be read on the local LCD or VAMPSET.

Channel, events codes and situations where events are generated:

134,1...134,10 Arc sensor 1...10 not conn. error on
134,11...134,20 Arc sensor 1...10 not conn. err off
134,21...134,30 Arc sensor 1...10 short circuit error on
134,31...134,40 Arc sensor 1...10 short circ. err off
134,41...134,50 Arc sensor 1...10 daylight error on
134,51...134,60 Arc sensor 1...10 daylight error off
135,1 I/O unit sensor error on (I/O unit + sensor number also shown)
135,2 I/O unit sensor error off (I/O unit + sensor number also shown)
135,3 I/O unit ArcI/O error on (I/O unit number also shown)
135,4 I/O unit ArcI/O error off (I/O unit number also shown)
135,9 I/O unit ArcI/O comm error on (I/O unit number also shown)
135,10 I/O unit ArcI/O comm error off (I/O unit number also shown)

Communication error between the VAMP 321 and I/O units is also shown by "COM 5 signal" in the output matrix and logics.

Only some of the communication protocols (IEC 61850, SPA-bus, Modbus and ModbusTCP) have capability to transfer all of these events. In some protocols only a selected subset can be trasferred or only status of COM5 is available with the help of logic programming.

4.5.1. Diagnostics

The device runs self-diagnostic tests for hardware and software in every boot sequence and also performs runtime checking.

Fatal errors

If fatal error has been detected, the device releases IF relay contact and error led is set on. Local panel will also display an error message about the detected fault. Fatal error state is entered when the device is not able to handle protections.

Runtime errors

When self-diagnostic function detects a fault, **Selfdiag Alarm** matrix signal is set and an event (E56) is generated. In case the error was only temporary, an off event is generated (E57). Self diagnostic error can be reset via local panel interface.

Error registers

There are four 16-bit error registers which are readable through remote protocols. The following table shows the meaning of each error register and their bits.

Register	Bit	Code	Description
SelfDiag1	0 (LSB)	T1	Output relay fault
	1	T2	
	2	T3	
	3	T4	
	4	A1	
SelfDiag3	0 (LSB)	DAC	mA-output fault
	1	STACK	OS: stack fault
	2	MemChk	OS: memory fault
	3	BGTask	OS: background task timeout
	4	DI	Digital input fault (DI1, DI2)
	5		
	6	Arc	Arc card fault
	7	SecPulse	Hardware error
	8	RangeChk	DB: Setting outside range
	9	CPULoad	OS: overload
	10	+24V	Internal voltage fault
	11	-15V	
	12	ITemp	Internal temperature too high
	13	ADChk1	A/D converter error
	14	ADChk2	A/D converter error
	15 (MSB)	E2prom	E2prom error
SelfDiag4	0 (LSB)	+12V	Internal voltage fault
	1	ComBuff	BUS: buffer error
	2	OrderCode	Order code error

The error code is displayed in self diagnostic events and on the diagnostic menu on local panel and VAMPSET.

5. Measurement functions

5.1. Measurements for arc protection function

The three phase current measurement and earth-fault current measurement for arc protection is done with electronics (see figure). The electronics compares the current levels to the pick-up settings - THRESHOLDs - and gives a binary signals "I>>" or "Io>>" to the arc protection function if limit is exceeded. All the frequency components of the currents are taken into account.

Signals "I>>" or "Io>>" are connected to a FPGA chip which implements the arc protection function. The pick-up settings are named "I> int" and "Io> int" in the local LCD panel or VAMPSET views, these settngs are used to set the THRESHOLD levels for the electronics.

Tha accuracy of the arc protection measurements is +/- 15% with 50Hz signal.

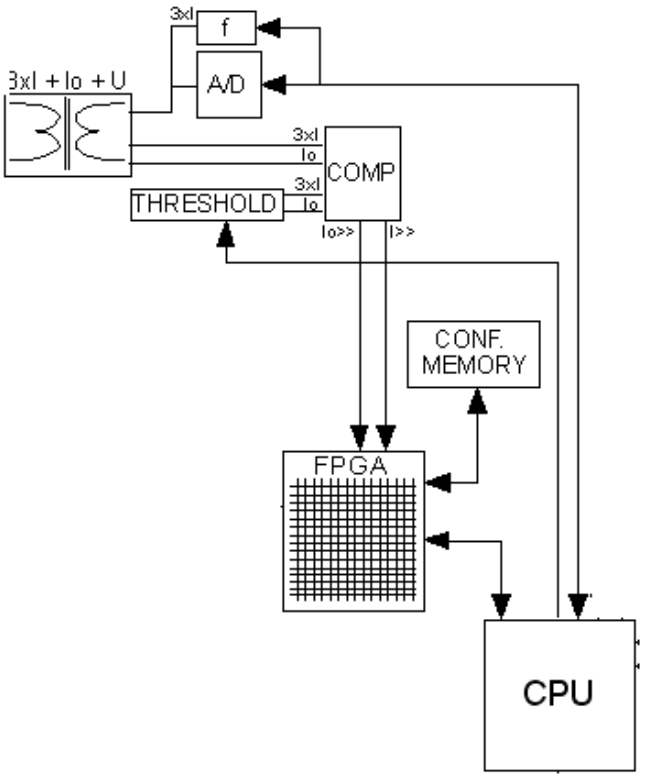


Figure 5.1-1 Measurement logic for the arc flash protection function.

5.2. Measurements for user interface, communication and other functions

All the direct measurements are based on fundamental frequency values. The exceptions are frequency and instantaneous current for arc protection. Most protection functions are also based on the fundamental frequency values.

The figure shows a current waveform and the corresponding fundamental frequency component f1, second harmonic f2 and rms value in a special case, when the current deviates significantly from a pure sine wave.

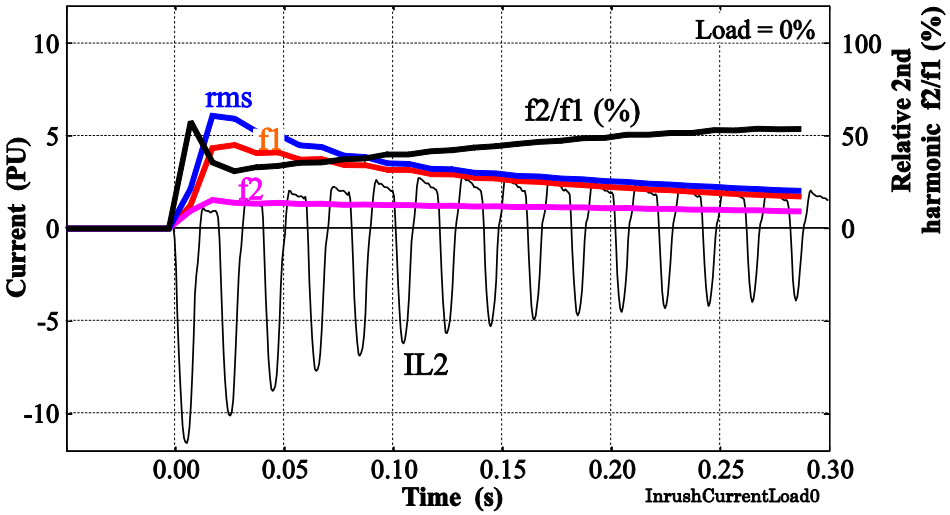


Figure 5.2-1 Example of various current values of a transformer inrush current.

5.3. Measurement accuracy

Phase current inputs I_{L1}, I_{L2}, I_{L3}

Measuring range		0.025 – 250 A
Inaccuracy	I ≤ 7.5 A	0.5 % of value or 15 mA
	I > 7.5 A	3 % of value

The specified frequency range is 45 Hz – 65 Hz.

Voltage input U

The usage of voltage inputs depends on the configuration parameter voltage measurement mode. For example, U is the zero sequence voltage input U_0 if the mode "U_0" is selected.

Measuring range	0.5 – 175 V
Inaccuracy	0.5 % or 0.3 V

The specified frequency range is 45 Hz – 65 Hz.

Residual current input I_0

Measuring range		0 – 10 xI_N
Inaccuracy	I ≤ 1.5 xI_N	0.3 % of value or 0.2 % of I_N
	I > 1.5 xI_N	3 % of value

The specified frequency range is 45 Hz – 65 Hz.

The rated input I_n is 5A, 1 A or 0.2 A. It is specified in the order code of the relay.

Frequency

Measuring range	16 Hz – 75 Hz
Inaccuracy	10 mHz

The frequency is measured from current signals.

THD and harmonics

Inaccuracy	I, U > 0.1 PU	2 % units
Update rate		Once a second

The specified frequency range is 45 Hz – 65 Hz.

NOTICE These measurement accuracies are not valid for the arc protection functions.

5.4. RMS values

RMS currents

The device calculates the RMS value of each phase current. The minimum and the maximum of RMS values are recorded and stored (see chapter 5.7).

$$I_{rms} = \sqrt{I_{f1}^{\ 2} + I_{f2}^{\ 2} + ... + I_{f15}^{\ 2}}$$

RMS voltages

The device calculates the RMS value of each voltage input. The minimum and the maximum of RMS values are recorded and stored (see chapter 5.7).

$$U_{rms} = \sqrt{U_{f1}^{\ 2} + U_{f2}^{\ 2} + ... + U_{f15}^{\ 2}}$$

5.5. Harmonics and Total Harmonic Distortion (THD)

The device calculates the THDs as percentage of the base frequency for currents and voltages.

The device calculates the harmonics from the 2nd to the 15th of phase currents and voltages. (The 17th harmonic component will also be shown partly in the value of the 15th harmonic component. This is due to the nature of digital sampling.)

The harmonic distortion is calculated using equation

$$THD = \frac{\sqrt{\sum_{i=2}^{15} h_i^2}}{h_1}$$, where

h_1 = Fundamental value

$h_{2...15}$ = Harmonics

Example

h_1 = 100 A

h_3 = 10 A

h_7 = 3 A

h_{11} = 8 A

$$THD = \frac{\sqrt{10^2 + 3^2 + 8^2}}{100} = 13.2\%$$

For reference the RMS value is:

$$RMS = \sqrt{100^2 + 10^2 + 3^2 + 8^2} = 100.9A$$

Another way to calculate THD is to use the RMS value as reference instead of the fundamental frequency value. In the example above the result would then be 13.0 %.

5.6. Demand values

The relay calculates average i.e. demand values of phase currents I_{L1}, I_{L2}, I_{L3} and power values S, P and Q. The demand time is configurable from 10 minutes to 30 minutes with parameter "Demand time".

Demand value parameters

Parameter	Value	Unit	Description	Set
Time	10 ... 30	min	Demand time (averaging time)	Set
Fundamental frequency values				
IL1da		A	Demand of phase current IL1	
IL2da		A	Demand of phase current IL2	
IL3da		A	Demand of phase current IL3	
Pda		kW	Demand of active power P	
PFda			Demand of power factor PF	
Qda		kvar	Demand of reactive power Q	
Sda		kVA	Demand of apparent power S	
RMS values				
IL1da		A	Demand of phase current IL1	
IL2da		A	Demand of phase current IL2	
IL3da		A	Demand of phase current IL3	

5.7. Minimum and maximum values

Minimum and maximum values are registered with time stamps since the latest manual clearing or since the device has been restarted. The available registered min & max values are listed in the following table.

Min & Max measurement	Description
IL1, IL2, IL3	Phase current (fundamental frequency value)
IL1RMS, IL2RMS, IL3RMS	Phase current, rms value
Io1	Residual current
U12	Line-to-line voltage
Uo	Zero sequence voltage
f	Frequency
P, Q, S	Active, reactive, apparent power
IL1da, IL2da, IL3da	Demand values of phase currents
IL1da, IL2da, IL3da (rms value)	Demand values of phase currents, rms values
PFda	Power factor demand value

NOTICE The availability of voltage measurements depens of the selected voltage measurement mode of the device.

The clearing parameter "ClrMax" is common for all these values.

Parameters

Parameter	Value	Description	Set
ClrMax	_ Clear	Reset all minimum and maximum values	S

5.8. Maximum values of the last 31 days and twelve months

Some maximum and minimum values of the last 31 days and the last twelve months are stored in the non-volatile memory of the relay. Corresponding time stamps are stored for the last 31 days. The registered values are listed in the following table.

Measurement	Max	Min	Description
IL1, IL2, IL3	X		Phase current (fundamental frequency value)
Io1	X		Residual current
S	X		Apparent power
P	X	X	Active power
Q	X	X	Reactive power

The value can be a one cycle value or an average according parameter "Timebase".

Parameters of the day and month registers

Parameter	Value	Description	Set
Timebase		Parameter to select the type of the registered values.	S
	20 ms	Collect min & max of one cycle values *)	
	200 ms	Collect min & max of 200 ms average values	
	1 s	Collect min & max of 1 s average values	
	1 min	Collect min & max of 1 minute average values	
	demand	Collect min & max of demand values (see chapter 5.6)	
ResetDays		Reset the 31 day registers	S
ResetMon		Reset the 12 month registers	S

*) This is the fundamental frequency rms value of one cycle updated every 20 ms.

5.9. Voltage measurement modes

Depending on the application and available voltage transformers, the relay can be connected either to zero-sequence voltage, one line-to-line voltage or one phase-to-ground voltage. The configuration parameter "Voltage measurement mode" must be set according the used connection.

The available modes are:

- "U_0"
  The device is connected to zero sequence voltage. Directional earth fault protection is available. Line voltage measurement, energy measurement and over- and undervoltage protection are not possible.
- "1LL"
  The device is connected to one line-to-line voltage. Single phase voltage measurement and over- and undervoltage protection are available. Directional earth fault protection is not possible.
- "1LN"
  The device is connected to one phase-to-ground voltage. Single phase voltage measurement is available. In low impedance grounded networks over- and undervoltage protection are available. Directional earth fault protection is not possible.

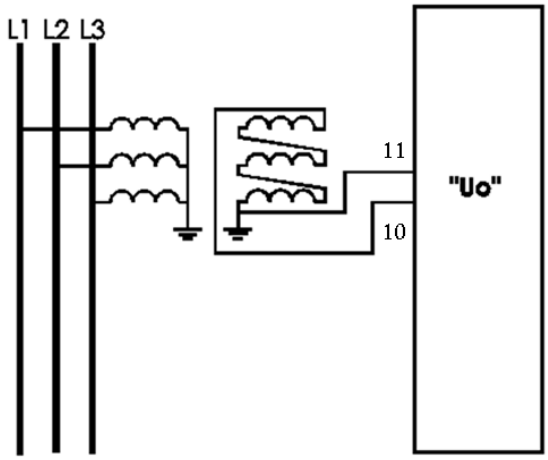


Figure 5.9-1 Broken delta connection in voltage measurement mode "U_0".

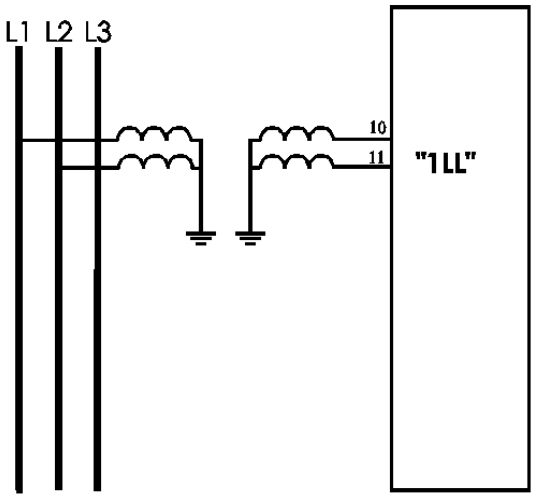


Figure 5.9-2 Line-to-line voltage in voltage measurement mode "1LL".

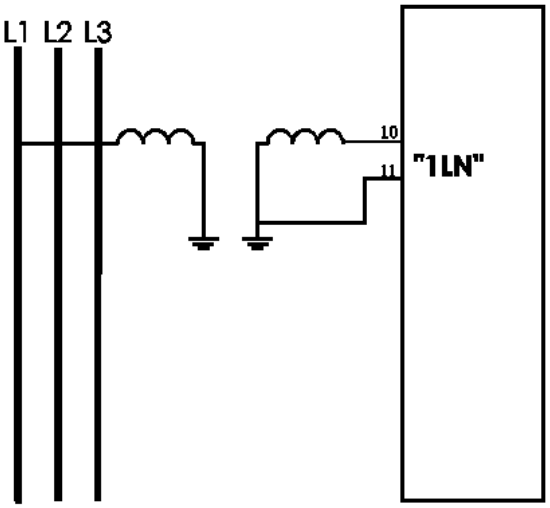


Figure 5.9-3 Phase-to-neutral voltage in voltage measurement mode "1LN".

5.10. Symmetric components

In a three phase system, the voltage or current phasors may be divided in symmetric components according C. L. Fortescue (1918). The symmetric components are:

- Positive sequence 1
- Negative sequence 2
- Zero sequence 0

Symmetric components are calculated according the following equations:

$$\begin{bmatrix} \underline{S}_0 \\ \underline{S}_1 \\ \underline{S}_2 \end{bmatrix} = \frac{1}{3} \begin{bmatrix} 1 & 1 & 1 \\ 1 & \underline{a} & \underline{a}^2 \\ 1 & \underline{a}^2 & \underline{a} \end{bmatrix} \begin{bmatrix} \underline{U} \\ \underline{V} \\ \underline{W} \end{bmatrix}$$, where

$\underline{S}_0$ = zero sequence component

$\underline{S}_1$ = positive sequence component

$\underline{S}_2$ = negative sequence component

$\underline{a} = 1\angle 120° = -\frac{1}{2} + j\frac{\sqrt{3}}{2}$, a phasor rotating constant

$\underline{U}$ = phasor of phase L1 (phase current)

$\underline{V}$ = phasor of phase L2

$\underline{W}$ = phasor of phase L3

5.11. Primary, secondary and per unit scaling

Many measurement values are shown as primary values although the relay is connected to secondary signals. Some measurement values are shown as relative values - per unit or per cent. Almost all pick-up setting values are using relative scaling. The scaling is done using the given CT, VT in feeder mode and furthermore motor name plate values in motor mode.

The following scaling equations are useful when doing secondary testing.

5.11.1. Current scaling

NOTICE

The rated value of the device's current input 5 A, does not have any effect in the scaling equations, but it defines the measurement range and the maximum allowed continuous current.

Primary and secondary scaling

	Current scaling
secondary ⇒ primary	$I_{PRI} = I_{SEC} \cdot \frac{CT_{PRI}}{CT_{SEC}}$
primary ⇒ secondary	$I_{SEC} = I_{PRI} \cdot \frac{CT_{SEC}}{CT_{PRI}}$

For residual current to input I_{01} use the corresponding CT_{PRI} and CT_{SEC} values. For earth fault stages using I_{0Calc} signals use the phase current CT values for CT_{PRI} and CT_{SEC}.

Example 1: Secondary to primary.

CT = 500/5

Current to the relay's input is 4 A.

⇒ Primary current is I_{PRI} = 4x500/5 = 400 A

Example 2: Primary to secondary.

CT = 500/5

The relay displays I_{PRI} = 400 A

⇒ Injected current is I_{SEC} = 400x5/500 = 4 A

Per unit [pu] scaling

For phase currents excluding ArcI> stage
1 pu = 1xI_{MODE} = 100 %, where
I_{MODE} is the rated current of the motor or the nominal value of the feeder.

For residual currents and ArcI> stage
1 pu = 1xCT_{SEC} for secondary side and
1 pu = 1xCT_{PRI} for primary side.

	Phase current scaling excluding ArcI> stage	**Residual current ($3I_0$) scaling and phase current scaling for ArcI> stage**
secondary ⇒ per unit	$I_{PU} = \frac{I_{SEC} \cdot CT_{PRI}}{CT_{SEC} \cdot I_{MODE}}$	$I_{PU} = \frac{I_{SEC}}{CT_{SEC}}$
per unit ⇒ secondary	$I_{SEC} = I_{PU} \cdot CT_{SEC} \cdot \frac{I_{MODE}}{CT_{PRI}}$	$I_{SEC} = I_{PU} \cdot CT_{SEC}$

Example 1: Secondary to per unit for phase currents excluding ArcI>.

CT = 750/5

I_{MODE} = 525 A

Current injected to the relay's inputs is 7 A.

⇒ Per unit current is
I_{PU} = 7x750/(5x525) = 2.00 pu = 2.00 xI_{MODE} = 200 %

Example 2: Secondary to per unit for ArcI>.

CT = 750/5

Current injected to the relay's inputs is 7 A.

⇒ Per unit current is
I_{PU} = 7/5 = 1.4 pu = 140 %

Example 3: Per unit to secondary for phase currents excluding ArcI>.

CT = 750/5

I_{MODE} = 525 A

The relay setting is 2xI_{MODE} = 2 pu = 200 %.

⇒ Secondary current is
I_{SEC} = 2x5x525/750 = 7 A

Example 4: Per unit to secondary for ArcI>.

CT = 750/5

The relay setting is 2 pu = 200 %.

⇒ Secondary current is
I_{SEC} = 2x5 = 10 A

Example 5: Secondary to per unit for residual current.

Input is I_{01}.

CT_0 = 50/1

Current injected to the relay's input is 30 mA.

⇒ Per unit current is

I_{PU} = 0.03/1 = 0.03 pu = 3 %

Example 6: Per unit to secondary for residual current.

Input is I_{01}.

CT_0 = 50/1

The relay setting is 0.03 pu = 3 %.

⇒ Secondary current is

I_{SEC} = 0.03x1 = 30 mA

Example 7: Secondary to per unit for residual current.

Input is I_{0Calc}.

CT = 750/5

Currents injected to the relay's I_{L1} input is 0.5 A.

$I_{L2} = I_{L3} = 0$.

⇒ Per unit current is

I_{PU} = 0.5/5 = 0.1 pu = 10 %

Example 8: Per unit to secondary for residual current.

Input is I_{0Calc}.

CT = 750/5

The relay setting is 0.1 pu = 10 %.

⇒ If $I_{L2} = I_{L3} = 0$, then secondary current to I_{L1} is

I_{SEC} = 0.1x5 = 0.5 A

5.11.2. Voltage scaling

Primary/secondary scaling of line-to-line voltages

	Line-to-line voltage scaling	
	Voltage measurement mode = "1LL"	Voltage measurement mode = "1LN"
secondary ⇒ primary	$U_{PRI} = U_{SEC} \cdot \frac{VT_{PRI}}{VT_{SEC}}$	$U_{PRI} = \sqrt{3} \cdot U_{SEC} \cdot \frac{VT_{PRI}}{VT_{SEC}}$
primary ⇒ secondary	$U_{SEC} = U_{PRI} \cdot \frac{VT_{SEC}}{VT_{PRI}}$	$U_{SEC} = \frac{U_{PRI}}{\sqrt{3}} \cdot \frac{VT_{SEC}}{VT_{PRI}}$

Example 1: Secondary to primary. Voltage measurement mode is "1LL".

VT = 12000/110

Voltage connected to the relay's input is 100 V.
⇒ Primary voltage is U_{PRI} = 100x12000/110 = 10909 V

Example 2: Secondary to primary. Voltage measurement mode is "1LN".
VT = 12000/110

The voltage connected to the relay's input is 57.7 V.
⇒ Primary voltage is U_{PRI} = √3x58x12000/110 = 10902 V

Example 3: Primary to secondary. Voltage measurement mode is "1LL".

VT = 12000/110

The relay displays U_{PRI} = 10910 V.
⇒ Secondary voltage is U_{SEC} = 10910x110/12000 = 100 V

Example 4: Primary to secondary. Voltage measurement mode is "1LN".

VT = 12000/110

The relay displays $U_{12} = U_{23} = U_{31}$ = 10910 V.
⇒ Secondary voltage is
U_{SEC} = 10910/√3x110/12000 = 57.7 V4

Per unit [pu] scaling of line-to-line voltages

One per unit = 1 pu = 1xU_N = 100 %, where U_N = rated voltage of the VT.

	Line-to-line voltage scaling	
	Voltage measurement mode = "1LL"	Voltage measurement mode = "1LN"
secondary ⇒ per unit	$U_{PU} = \frac{U_{SEC}}{VT_{SEC}}$	$U_{PU} = \sqrt{3} \cdot \frac{U_{SEC}}{VT_{SEC}}$
per unit ⇒ secondary	$U_{SEC} = U_{PU} \cdot VT_{SEC}$	$U_{SEC} = U_{PU} \cdot \frac{VT_{SEC}}{\sqrt{3}}$

Example 1: Secondary to per unit. Voltage measurement mode is "1LL".

VT = 12000/110

$U_N = VT_{PRI}$

Voltage connected to the relay's input is 110 V.
⇒ Per unit voltage is

U_{PU} = 110/110 = 1.00 pu = 1.00xU_{MODE} = 100 %

Example 2: Secondary to per unit. Voltage measurement mode is "1LN".

VT = 12000/110

Phase-to-neutral voltage connected to the relay's input is 63.5 V.
⇒ Per unit voltage is

U_{PU} = √3x63.5/110x12000/11000 = 1.00 pu = 1.00xU_N =100 %

Example 3: Per unit to secondary. Voltage measurement mode is "1LL".

VT = 12000/110

The relay displays 1.00 pu = 100 %.
⇒ Secondary voltage is

U_{SEC} = 1.00x110x11000/12000 = 100.8 V

Example 4: Per unit to secondary. Voltage measurement mode is "1LN".

VT = 12000/110

The relay displays 1.00 pu = 100 %.

⇒ Phase-to-neutral voltage connected to the relay's input is

U_{SEC} = 1.00x110/√3x11000/12000 = 63.5 V

Per unit [pu] scaling of zero sequence voltage

	Zero-sequence voltage (U_0) scaling
	Voltage measurement mode = "U_0"
secondary ⇒ per unit	$U_{PU} = \frac{U_{SEC}}{U_{0SEC}}$
per unit ⇒ secondary	$U_{SEC} = U_{PU} \cdot U_{0SEC}$

Example 1: Secondary to per unit. Voltage measurement mode is "U_0".
U_{0SEC} = 110 V (This is a configuration value corresponding to U_0 at full earth fault.)
Voltage connected to the relay's input is 22 V.
⇒ Per unit voltage is
U_{PU} = 22/110 = 0.20 pu = 20 %

6. Control functions

6.1. Output relays

The output relays are also called digital outputs. Any internal signal can be connected to the output relays using output matrix and/or ARC MATRIX - OUTPUT. An output relay can be configured as latched or non-latched.

The difference between trip contacts and alarm contacts is the DC breaking capacity. The contacts are normal open type (NO), except alarm relay A1 which has change over contact.

Parameters of output relays

Parameter	Value	Unit	Description	Note
T1 ...Tx the available parameter list depends on the number and type of the I/O cards.	0 1		Status of trip output relay	F
A1	0 1		Status of alarm output relay	F
IF	0 1		Status of the internal fault indication relay	F
Force	On Off		Force flag for output relay forcing for test purposes. This is a common flag for all output relays and protection stage status, too. Any forced relay(s) and this flag are automatically reset by a 5-minute timeout.	Set
REMOTE PULSES				
A1	0.00 ... 99.98 or 99.99	s	Pulse length for direct output relay control via communications protocols. 99.99 s = Infinite. Release by writing "0" to the direct control parameter	Set
NAMES for OUTPUT RELAYS (editable with VAMPSET only)				
Description	String of max. 32 characters		Names for DO on VAMPSET screens. Default is "Trip relay n", n=1...4 or "Alarm relay n", n=1	Set

Set = An editable parameter (password needed)

F = Editable when force flag is on

6.2. Digital inputs

Digital inputs are available for control purposes. The number of available inputs depends on the number and type of I/O cards. The polarity – normal open (NO) / normal closed (NC – and a delay can be configured according the application. The signals are available for the output matrix, block matrix, user's programmable logic etc.

The digital inputs need an external control voltage (ac or dc). The voltage nominal activation level can be selected in the ordering code.

Selection in order code	Nominal voltage
1	24 V dc / 110 V ac
2	110 V dc / 220 V ac
3	220 V dc

When 110 or 220 V ac voltage is used to activate the digital Inputs, the AC mode should be selected as shown in the screenshot below:

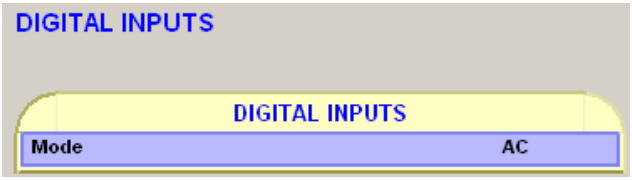


Figure 6.2-1 AC mode selection in VAMPSET

These inputs are ideal for transferring the status information of switching devices into the device.

Label and description texts can be edited with VAMPSET according the application. Labels are the short parameter names used on the local panel and descriptions are the longer names used by VAMPSET.

NOTICE

The high-speed arc flash protection functions utilize binary input signals (BI) instead of the digital inputs (read more in chapter "Arc flash protection" and in chapter "Binary inputs and outputs".)

Parameters of digital inputs

Parameter	Value	Unit	Description	Set
DI1...Dx	0 1		Status of digital input	
DI COUNTERS				
DI1…Dx	0 ... 65535		Cumulative active edge counter	(Set)
DELAYS FOR DIGITAL INPUTS				
DI1…	0.00 ... 60.00	s	Definite delay for both on and off transitions	Set
CONFIGURATION Digital Inputs				
Inverted	no yes		For normal open contacts (NO). Active edge is 0⇒1 For normal closed contacts (NC) Active edge is 1⇒0	Set
Alarm display	no yes		No pop-up display Alarm pop-up display is activated at active DI edge	Set
On event	On Off		Active edge event enabled Active edge event disabled	Set
Off event	On Off		Inactive edge event enabled Inactive edge event disabled	Set
NAMES for DIGITAL INPUTS (editable with VAMPSET only)				
Label	String of max. 10 characters		Short name for DIs on the local display Default is "DIn", n=1...2	Set
Description	String of max. 32 characters		Long name for DIs. Default is "Digital input n", n=1...2	Set

Set = An editable parameter (password needed)

6.3. Binary inputs and outputs

Information from the arc protection function can be transmitted and/or received through binary inputs (BI) and outputs (BO). The rated voltage of these signals is 30 V dc when active. The input signal has to be 18 … 42 V dc to be activated.

Binary inputs

The binary inputs (BI) can be used to get the light indication from another IED to build selective arc protection systems. BI is a dry input for 18…42 V dc signal. The connection of BI signals is configured in the matrices of the arc flash protection function.

Binary output

The binary outputs (BO) can be used to give the light indication signal or any other signal or signals to another IED's binary input to build selective arc protection systems. BO is an internally wetted 30 Vdc signal. The connection of BO signals is configured in the matrices of the arc flash protection function.

6.4. Virtual inputs and outputs

There are virtual inputs and virtual outputs, which can in many places be used like their hardware equivalents execpt that they are only located in the memory of the device. The virtual inputs acts like normal digital inputs. The state of the virtual input can be changed from display, communication bus and from VAMPSET. For example setting groups can be changed using virtual inputs.

Parameters of virtual inputs

Parameter	Value	Unit	Description	Set
VI1 ... VIx	0 1		Status of virtual input	
Events	On Off		Event enabling	Set
NAMES for VIRTUAL INPUTS (editable with VAMPSET only)				
Label	String of max. 10 characters		Short name for VIs on the local display Default is "VIn", n=1...4	Set
Description	String of max. 32 characters		Long name for VIs. Default is "Virtual input n", n=1...4	Set

Set = An editable parameter (password needed)

The virtual outputs do act like output relays, but there are no physical contacts. Virtual outputs are shown in the output matrix and the block matrix. Virtual outputs can be used with the user's programmable logic and to change the active setting group etc.

6.5. Function keys / F1 & F2

There are two (2) function keys (F1 and F2) available in the device front panel. As default, these keys are programmed to toggle VI1 and VI2.

It is possible to change F1 & F2 to toggle other VI's or to act as object control. Selection of F1 & F2 function is done with VAMPSET software under the menu "FUNCTION BUTTONS".

Parameters of function keys

Parameter	Value	Unit	Description	Set
Selected control	VI1 : VI4 Object control		Function key toggles virtual input 1 : Function key toggles virtual input 4 Function key acts as object control and key can be selected as "DI for local open/close control"	Set

6.6. Output matrix

By means of the output matrix, the output signals of the various protection stages, digital inputs, logic outputs and other internal signals can be connected to the output relays, virtual outputs etc.

NOTICE For configuring the high-speed operations of the arc protection the "ARC MATRIX – OUTPUT" must be used.

There are general purpose LED indicators – "A", "B", "C",…."N" – available for customer-specific indications on the front panel. Their usage is define in a separate LED MATRIX.

Furthermore there are two LED indicators specified for keys F1 and F2. In addition, the triggering of the disturbance recorder (DR) and virtual outputs are configurable in the output matrix. See an example in Figure 6.6-1.

An output relay or indicator LED can be configured as latched or non-latched. A non-latched relay follows the controlling signal. A latched relay remains activated although the controlling signal releases.

There is a common "release latched" signal to release all the latched relays. This release signal resets all the latched output relays and indicators. The reset signal can be given via a digital input, via a keypad or through communication. Any digital input can be used for resetting. The selection of the input is done with the VAMPSET software under the menu "Release output matrix latches". Under the same menu, the "Release latches" parameter can be used for resetting.

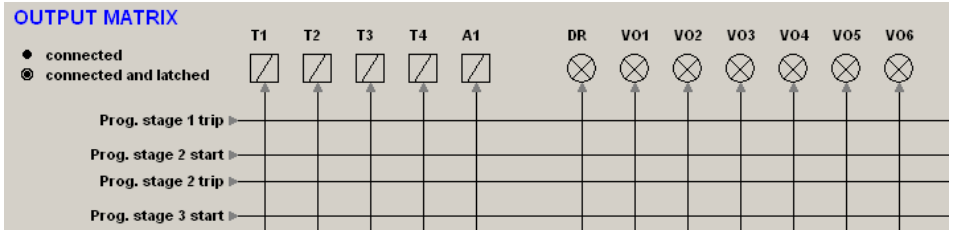


Figure 6.6-1 Output matrix.

6.7. Blocking matrix

By means of a blocking matrix, the operation of any protection stage (except the arc protection stages) can be blocked. The blocking signal can originate from the digital inputs or it can be a start or trip signal from a protection stage or an output signal from the user's programmable logic. In the block matrix Figure 6.7-1 an active blocking is indicated with a black dot (•) in the crossing point of a blocking signal and the signal to be blocked.

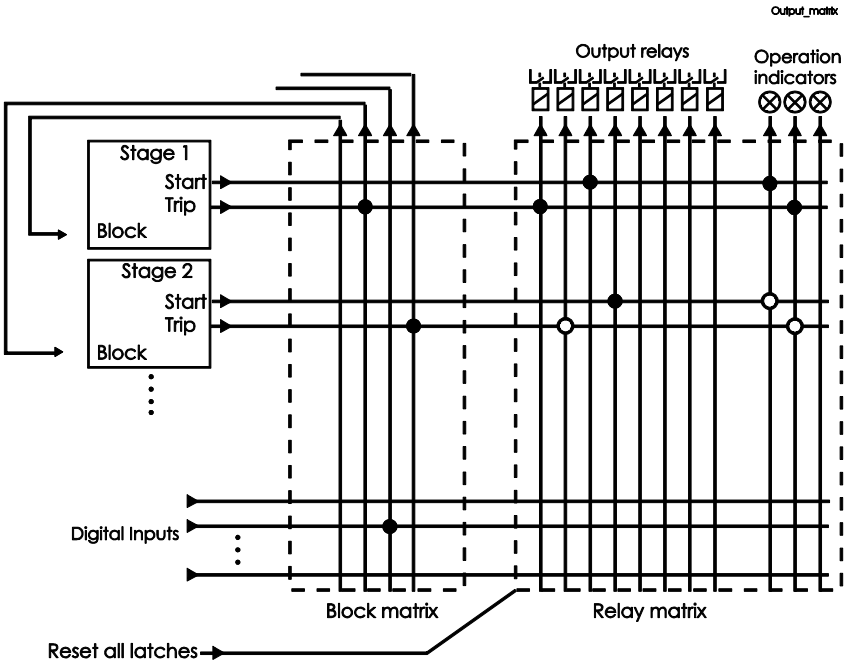


Figure 6.7-1 Blocking matrix and output matrix

NOTICE Blocking matrix cannot be used to block the arc protection stages.

6.8. Controllable objects

The device allows controlling of six objects, that is, circuit-breakers, disconnectors and earthing switches. Controlling can be done by "select-execute" or "direct control" principle.

The logic functions can be used to configure interlocking for a safe controlling before the output pulse is issued. The objects 1...6 are controllable while the objects 7...8 are only able to show the status.

Controlling is possible by the following ways:

- through the local HMI
- through a remote communication
- through a digital input
- through the function key

The connection of an object to specific output relays is done via an output matrix (object 1-6 open output, object 1-65 close output). There is also an output signal "Object failed", which is activated if the control of an object fails.

Object states

Each object has the following states:

Setting	Value	Description
Object state	Undefined (00)	Actual state of the object
	Open	
	Close	
	Undefined (11)	

Basic settings for controllable objects

Each controllable object has the following settings:

Setting	Value	Description
DI for 'obj open'	None, any digital input, virtual input or virtual output	Open information
DI for 'obj close'		Close information
DI for 'obj ready'		Ready information
Max ctrl pulse length	0.02 … 600 s	Pulse length for open and close commands
Completion timeout	0.02 … 600 s	Timeout of ready indication
Object control	Open/Close	Direct object control

If changing states takes longer than the time defined by "Max ctrl pulse length" setting, object fails and "Object failure" matrix signal is set. Also undefined-event is generated. "Completion timeout" is only used for the ready indication. If "DI for 'obj ready'" is not set, completion timeout has no meaning.

Output signals of controllable objects

Each controllable object has 2 control signals in matrix:

Output signal	Description
Object x Open	Open control signal for the object
Object x Close	Close control signal for the object

These signals send control pulse when an object is controlled by digital input, remote bus, auto-reclose etc.

Settings for read-only objects

Each read-only object has the following settings:

Setting	Value	Description
DI for 'obj open'	None, any digital input, virtual input or virtual output	Open information
DI for 'obj close'		Close information
Object timeout	0.02 … 600 s	Timeout for state changes

If changing states takes longer than the time defined by "Object timeout" setting, object fails and "Object failure" matrix signal is set. Also undefined-event is generated.

Controlling with DI

Objects can be controlled with digital input, virtual input or virtual output. There are four settings for each controllable object:

Setting	Active
DI for remote open control	In remote state
DI for remote close control	
DI for local open control	In local state
DI for local close control	

If the device is in local control state, the remote control inputs are ignored and vice versa. Object is controlled when a rising edge is detected from the selected input. Length of digital input pulse should be at least 60 ms.

Controlling with F1 & F2

Objects can be controlled with F1 & F2. There are two settings for each controllable object:

Setting	Active
DI for local open control	In local state
DI for local close control	

Selected object and control is shown in VAMPSET software under the menu "FUNCTION BUTTONS". If no object with local control is selected '-' is shown. If multiple local controls are selected for one key '?' is shown.

6.8.1. Local/Remote selection

In Local mode, the output relays can be controlled via a local HMI, but they cannot be controlled via a remote serial communication interface.

In Remote mode, the output relays cannot be controlled via a local HMI, but they can be controlled via a remote serial communication interface.

The selection of the Local/Remote mode is done by using a local HMI, or via one selectable digital input. The digital input is normally used to change a whole station to a local or remote mode. The selection of the L/R digital input is done in the "Objects" menu of the VAMPSET software.

NOTICE A password is not required for a remote control operation.

6.9. Logic functions

The device supports customer-defined programmable logic for boolean signals. The logic is designed by using the VAMPSET setting tool and downloaded to the device. Functions available are:

- AND
- OR
- XOR
- NOT
- COUNTERs
- RS & D flip-flops

Maximum number of outputs is 20. Maximum number of input gates is 31. An input gate can include any number of inputs.

For detailed information, please refer to the VAMPSET manual (VMV.EN0xx).

7. Communication

7.1. Communication ports

The device has two fixed communcation ports: USB port for connection to VAMPSET setting and configuration tool and COM 5 port (Arc I/O Bus) for communication with the arc protection I/O-units

Optionally the device may have upto to 4 serial ports COM 1, COM 2, COM 3 and COM 4 for serial protocols (for example IEC 103) and one ETHERNET port for Ethernet-based communication protocols (for example IEC 61850).

The number of available serial ports depends on the type of the communication option cards in Slot 9 and Slot 10.

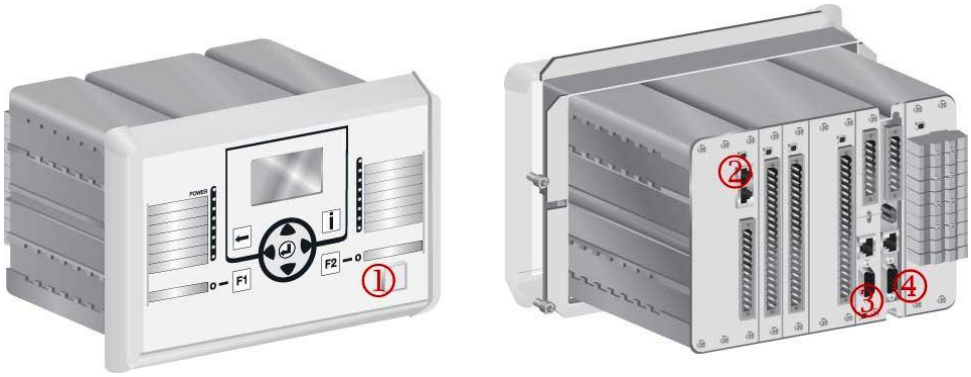


Figure 7.1-1. Communication ports and connectors.

1-USB interface for VAMPSET
2-COM 5 (Arc I/O Bus) interface
3-Communication interface I (Slot 9)
4-Communication interface II (Slot 10)

NOTICE COM5 is not an Ethernet interface.

7.1.1. USB port (Front panel)

The relay has a USB-connector in the front panel

Protocol for the USB port

The front panel USB port is always using the command line protocol for VAMPSET. The protocol is an ASCII character protocol called "GetSet". The speed of the interface is defined in CONF/DEVICE SETUP menu from the local HMI. The default settings for the relay are 38400/8N1.

Physical interface

The physical interface of this port is USB.

7.1.2. COM 1….COM 4 ports

COM 1…COM 4 are serial ports for communication with protocols like IEC 103. The type of the physical interface on these ports depends on the type of the selected communication option module. The use of some protocols may require a certain type of option module for example ProfibusDP can only be used with external profibus module VPA 3CG, if the hardware interface of the COM port is RS-232.

The parameters for these ports are set via local HMI or with VAMPSET in menus COM 1 PORT….COM 4 PORT.

Parameters

Parameter	Value	Unit	Description	Note
Protocol	None SPA-bus ProfibusDP ModbusSlv IEC-103 ExternalIO IEC 101 DNP3 DeviceNet GetSet		Protocol selection for remote port - SPA-bus (slave) Interface to Profibus DB module VPA 3CG (slave) Modbus RTU slave IEC-60870-5-103 (slave) Modbus RTU master for external I/O-modules IEC-608670-5-101 DNP 3.0 Interface to DeviceNet module VSE 009 Communicationi protocola for VAMPSET interface	Set
Msg#	0 ... 2^{32}–1		Message counter since the device has restarted or since last clearing	Clr
Errors	0 ... 2^{16}–1		Protocol errors since the device has restarted or since last clearing	Clr
Tout	0 ... 2^{16}–1		Timeout errors since the device has restarted or since last clearing	Clr
	speed/DPS		Display of current communication parameters. speed = bit/s D = number of data bits P = parity: none, even, odd S = number of stop bits	1)

Set = An editable parameter (password needed)

Clr = Clearing to zero is possible

1) The communication parameters are set in the protocol specific menus. For the local port command line interface the parameters are set in configuration menu.

7.1.3. Ethernet Port

Ethernet Port is used for protocols like IEC61850 and Modbus TCP. The type of the physical interface on this port depends on the type of the selected communication option module.

Parameters

Parameter	Value	Unit	Description	Set
Protocol	 None ModbusTCPs DNP3 IEC 61850 EtherNetIP		Protocol selection for the Ethernet port. No protocol selected Modbus TCP slave DNP/TCP IEC-61850 protocol Ethernet/IP protocol	Set
Port	Nnn		Ip port for protocol, default 102	Set
IpAddr	n.n.n.n		Internet protocol address (set with VAMPSET)	Set
NetMsk	n.n.n.n		Net mask (set with VAMPSET)	Set
atew	default = 0.0.0.0		Gateway IP address (set with VAMPSET)	Set
NTPSvr	n.n.n.n		Network time protocol server (set with VAMPSET) 0.0.0.0 = no SNTP	Set
VS Port	Nn		IP port for VAMPSET	Set
KeepAlive	Nn		TCP keepalive interval	Set
MAC	nnnnnnnnnnnn		MAC address	
Msg#	Nnn		Message counter	
Errors	Nnn		Error counter	
Tout	Nnn		Timeout counter	

Set = An editable parameter (password needed)

7.2. Communication protocols

The protocols enable the transfer of the following type of data:

- events
- status information
- measurements
- control commands.
- clock synchronizing
- Settings (SPA-bus and embedded SPA-bus only)

7.2.1. GetSet

This is and ASCII protocol used by VAMPSET. This protocol is the protocol used on the USB port. This can also be used on the COM ports, if VAMPSET interface via these ports is required.

7.2.2. Modbus TCP and Modbus RTU

These Modbus protocols are often used in power plants and in industrial applications. The difference between these two protocols is the media. Modbus TCP uses Ethernet and Modbus RTU uses asynchronous communication (RS-485, optic fibre, RS-232).

VAMPSET will show the list of all available data items for Modbus. A separate document “Modbus data.pdf“ is also available.

The Modbus communication is activated usually for remote port via a menu selection with parameter "Protocol". See chapter 7.1.

For ethernet interface configuration see chapter “Ethernet port”.

Parameters

Parameter	Value	Unit	Description	Note
Addr	1 – 247		Modbus address for the device. Broadcast address 0 can be used for clock synchronizing. Modbus TCP uses also the TCP port settings.	Set
bit/s	1200 2400 4800 9600 19200	bps	Communication speed for Modbus RTU	Set
Parity	None Even Odd		Parity for Modbus RTU	Set

Set = An editable parameter (password needed)

7.2.3. Profibus DP

The Profibus DP protocol is widely used in industry. An external VPA 3CG and VX067 cable is required.

Device profile "continuous mode"

In this mode the device is sending a configured set of data parameters continuously to the Profibus DP master. The benefit of this mode is the speed and easy access to the data in the Profibus master. The drawback is the maximum buffer size of 128 bytes, which limits the number of data items transferred to the master. Some PLCs have their own limitation for the Profibus buffer size, which may further limit the number of transferred data items.

Device profile "Request mode"

Using the request mode it is possible to read all the available data from the VAMP device and still use only a very short buffer for Profibus data transfer. The drawback is the slower overall speed of the data transfer and the need of increased data processing at the Profibus master as every data item must be separately requested by the master.

NOTICE In request mode it is not possible to read continuously only one single data item. At least two different data items must be read in turn to get updated data from the device.

There is a separate manual for VPA 3CG for the continuous mode and request mode.

Available data

VAMPSET will show the list of all available data items for both modes. A separate document “Profibus parameters.pdf” is also available.

The Profibus DP communication is activated usually for remote port via a menu selection with parameter "Protocol". See chapter 7.1.

Parameters

Parameter	Value	Unit	Description	Note
Mode	 Cont Reqst		Profile selection Continuous mode Request mode	Set
bit/s	2400	bps	Communication speed from the main CPU to the Profibus converter. (The actual Profibus bit rate is automatically set by the Profibus master and can be up to 12 Mbit/s.)	
Emode	 Channel (Limit60) (NoLimit)		Event numbering style. Use this for new installations. (The other modes are for compatibility with old systems.)	(Set)
InBuf		bytes	Size of Profibus master's Rx buffer. (data to the master)	1) 3)
OutBuf		bytes	Size of Profibus master's Tx buffer. (data from the master)	2) 3)
Addr	1 – 247		This address has to be unique within the Profibus network system.	Set
Conv	 – VE		Converter type No converter recognized Converter type "VE" is recognized	 4)

Set = An editable parameter (password needed)

Clr = Clearing to zero is possible

1) In continuous mode the size depends of the biggest configured data offset of a data item to be send to the master. In request mode the size is 8 bytes.

2) In continuous mode the size depends of the biggest configured data offset of a data to be read from the master. In request mode the size is 8 bytes.

3) When configuring the Profibus master system, the lengths of these buffers are needed. The device calculates the lengths according the Profibus data and profile configuration and the values define the in/out module to be configured for the Profibus master.

4) If the value is "–", Profibus protocol has not been selected or the device has not restarted after protocol change or there is a communication problem between the main CPU and the Profibus ASIC.

7.2.4. SPA-bus

The device has full support for the SPA-bus protocol including reading and writing the setting values. Also reading of multiple consecutive status data bits, measurement values or setting values with one message is supported.

Several simultaneous instances of this protocol, using different physical ports, are possible, but the events can be read by one single instance only.

There is a separate document "Spabus parameters.pdf" of SPA-bus data items available.

Parameters

Parameter	Value	Unit	Description	Note
Addr	1 – 899		SPA-bus address. Must be unique in the system.	Set
bit/s	1200 2400 4800 9600 (default) 19200	bps	Communication speed	Set
Emode	Channel (Limit60) (NoLimit)		Event numbering style. Use this for new installations. (The other modes are for compatibility with old systems.)	(Set)

Set = An editable parameter (password needed)

7.2.5. IEC 60870-5-103

The IEC standard 60870-5-103 "*Companion standard for the informative interface of protection equipment*" provides standardized communication interface to a primary system (master system).

The unbalanced transmission mode of the protocol is used, and the device functions as a secondary station (slave) in the communication. Data is transferred to the primary system using "data acquisition by polling"-principle. The IEC functionality includes the following application functions:

- station initialization
- general interrogation
- clock synchronization and
- command transmission.

It is not possible to transfer parameter data or disturbance recordings via the IEC 103 protocol interface.

The following ASDU (Application Service Data Unit) types will be used in communication from the device:

- ASDU 1: time tagged message
- ASDU 3: Measurands I
- ASDU 5: Identification message
- ASDU 6: Time synchronization and
- ASDU 8: Termination of general interrogation.

The device will accept:

- ASDU 6: Time synchronization
- ASDU 7: Initiation of general interrogation and
- ASDU 20: General command.

The data in a message frame is identified by:

- type identification
- function type and
- information number.

These are fixed for data items in the compatible range of the protocol, for example, the trip of I> function is identified by: type identification = 1, function type = 160 and information number = 90. "Private range" function types are used for such data items, which are not defined by the standard (e.g. the status of the digital inputs and the control of the objects).

The function type and information number used in private range messages is configurable. This enables flexible interfacing to different master systems.

For more information on IEC 60870-5-103 in Vamp devices refer to the "IEC103 Interoperability List" document.

Parameters

Parameter	Value	Unit	Description	Note
Addr	1 – 254		An unique address within the system	Set
bit/s	9600 19200	bps	Communication speed	Set
MeasInt	200 – 10000	ms	Minimum measurement response interval	Set
SyncRe	Sync Sync+Proc Msg Msg+Proc		ASDU6 response time mode	Set

Set = An editable parameter (password needed)

Parameters for disturbance record reading

Parameter	Value	Unit	Description	Note
ASDU23	On Off		Enable record info message	Set
Smpls/msg	1–25		Record samples in one message	Set
Timeout	10–10000	s	Record reading timeout	Set
Fault			Fault identifier number for IEC-103. Starts + trips of all stages.	
TagPos			Position of read pointer	
Chn			Active channel	
ChnPos			Channel read position	
Fault numbering				
Faults			Total number of faults	
GridFlts			Fault burst identifier number	
Grid			Time window to classify faults together to the same burst.	Set

Set = An editable parameter (password needed)

7.2.6. DNP 3.0

The relay supports communication using DNP 3.0 protocol.

The following DNP 3.0 data types are supported:

- binary input
- binary input change
- double-bit input
- binary output
- analog input
- counters

Additional information can be obtained from the "DNP 3.0 Device Profile Document" and "DNP 3.0 Parameters.pdf".

DNP 3.0 communication is activated via menu selection. RS-485 interface is often used but also RS-232 and fibre optic interfaces are possible.

Parameters

Parameter	Value	Unit	Description	Set
bit/s	4800 9600 (default) 19200 38400	bps	Communication speed	Set
Parity	None (default) Even Odd		Parity	Set
SlvAddr	1 – 65519		An unique address for the device within the system	Set
MstrAddr	1 – 65519 255=default		Address of master	Set
LLTout	0 – 65535	ms	Link layer confirmation timeout	Set
LLRetry	1 – 255 1=default		Link layer retry count	Set
APLTout	0 – 65535 5000=default	ms	Application layer confirmation timeout	Set
CnfMode	EvOnly (default) All		Application layer confirmation mode	Set
DBISup	No (default) Yes		Double-bit input support	Set
SyncMode	0 – 65535	s	Clock synchronization request interval. 0 = only at boot	Set

Set = An editable parameter (password needed)

7.2.7. IEC 60870-5-101

The IEC 60870-5-101 standard is derived from the IEC 60870-5 protocol standard definition. In Vamp devices, IEC 60870-5-101 communication protocol is available via menu selection. The Vamp unit works as a controlled outstation (slave) unit in unbalanced mode.

Supported application functions include process data transmission, event transmission, command transmission, general interrogation, clock synchronization, transmission of integrated totals, and acquisition of transmission delay.

For more information on IEC 60870-5-101 in Vamp devices refer to the "IEC 101 Profile checklist & datalist" document.

Parameters

Parameter	Value	Unit	Description	Note
bit/s	1200 2400 4800 9600	bps	Bitrate used for serial communication.	Set
Parity	None Even Odd		Parity used for serial communication	Set
LLAddr	1 – 65534		Link layer address	Set
LLAddrSize	1 – 2	bytes	Size of Link layer address	Set
ALAddr	1 – 65534		ASDU address	Set
ALAddrSize	1 – 2	Bytes	Size of ASDU address	Set
IOAddrSize	2 – 3	Bytes	Information object address size. (3-octet addresses are created from 2-octet addresses by adding MSB with value 0.)	Set
COTsize	1	Bytes	Cause of transmission size	
TTFormat	Short Full		The parameter determines time tag format: 3-octet time tag or 7-octet time tag.	Set
MeasFormat	Scaled Normalized		The parameter determines measurement data format: normalized value or scaled value.	Set
DbandEna	No Yes		Dead-band calculation enable flag	Set
DbandCy	100 – 10000	ms	Dead-band calculation interval	Set

Set = An editable parameter (password needed)

7.2.8. External I/O (Modbus RTU master)

External Modbus I/O devices can be connected to the relay using this protocol.

7.2.9. IEC 61850

IEC 61850 protocol is available with the optional communication module. IEC 61850 protocol can be used to read / write static data from the relay to receive events and to receive / send GOOSE messages to other relays.

IEC 61850 serve interface is capable of.

- Configurable data model: selection of logical nodes corresponding to active application functions
- Configurable pre-defined data sets
- Supported dynamic data sets created by clients
- Supported reporting function with buffered and unbuffered Report Control Blocks
- Supported control model: direct with normal security
- Supported horizontal communication with GOOSE: configurable GOOSE publisher data sets, configurable filters for GOOSE subscriber inputs, GOOSE inputs available in the application logic matrix

Additional information can be obtained from the separate documents “IEC 61850 conformance statement.pdf”, “IEC 61850 Protocol data.pdf” and “Configuration of IEC 61850 interface.pdf” on our website.

IEC 61850 main config parameters

Parameter	Value	Unit	Description	Set
Port	0 – 64000		IP protocol port	Set
Check upper addresses	Yes / No		If the checkbox 'Check upper addresses' is checked the below parameters are also checked and used for addressing when the client is communicating to the device, by default this is disabled.	Set
.			The below parameters are ACSE association parameters described in the standard part 61850-8-1	
AP ID	nnn.nnn.nnn.nnn		ACSE AP title value	Set
AE Qualifier	0 – 64000		ACSE AE qualifier	
P Selector	0 – 4200000000		Presentation selector	
S Selector	0 – 64000		Session selector	
T Selector	0 – 64000		Transport selector	
IED Name	String		Identifcation of the device. Each device must have unique name.	
Delete dynamic datasets	Command		Send command to clear all dynamic datasets	

7.2.10. EtherNet/IP

The device supports communication using EtherNet/IP protocol which is a part of CIP (Common Industrial Protocol) family. EtherNet/IP protocol is available with the optional inbuilt Ethernet port. The protocol can be used to read / write data from the device using request / response communication or via cyclic messages transporting data assigned to assemblies (sets of data).

EtherNet/IP main features:

- Static data model: 2 standard objects (Overload and Control Supervisor), 2 private objects (one for digital data and one for analog data) and 4 configuration objects for protection functions configuration
- Two configurable assemblies (one producing and one consuming) with the maximum capacity of 128 bytes each EDS file that can be fed to any client supporting EDS files: can be generated at any time, all changes to EtherNet/IP configuration (see configuration parameters in table below) or to assemblies' content require generating of the new EDS file.
- Three types of communications are supported: UCMM (one time request / response), Class 3 connection (cyclic request / response) and Class 1 connection (cyclic IO messages containing assemblies' data)

EtherNet/IP implementation on VAMP device serves as a server and is not capable of initiating communication.

EtherNet/IP main configuration parameters:

Parameter	Range	Description
IP address		IP protocol address identifing device in the network
Multicast IP		Multicast IP address used for sending IO messages
Multicast TTL	1-100	Time to live of the IO messages sent to multicast address
Vendor ID	1-65535	Identification of a vendor by number
Device Type	0-65535	Indication of general type of product
Product Code	1-65535	Identification of a particular product of an individual vendor
Major Revision	1-127	Major revision of the item the Identity Object represents
Minor Revision	1-255	Minor revision of the item the Identity Object represents
Serial Number	0-4294967295	Serial number of device
Product Name	32 chars	Human readable identification
Producing Instance	1-1278	Instance number of producing assembly
Include Run/Idle Header (Producing)	On/Off	Include or exlude Run/Idle Header in an outgoing IO messages
Consuming Instance	1-1278	Instance number of consuming assembly
Include Run/Idle Header (Consuming)	On/Off	Expect presence or absence of Run/Idle Header in an incoming IO messages

8. Application example

8.1. VAMP 321 multizone arc flash protection system

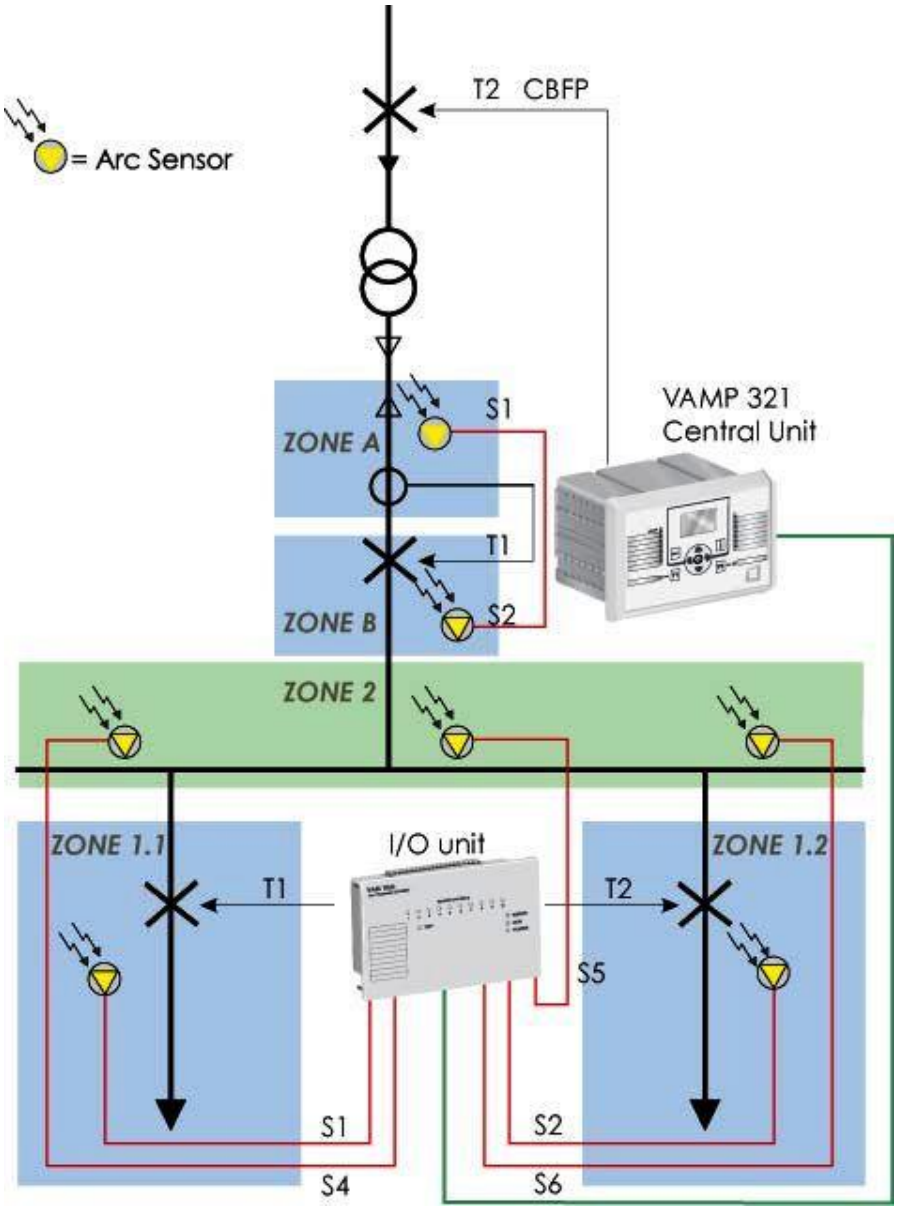


Figure 8.1-1 VAMP 321 application example. The current transformer value is 1200/5 A

Zone A	Cable compartment of the incoming feeder
Zone B	Circuit-breaker compartment
Zone 1	Busbar compartment
Zone 1.1/ Zone 1.2	Combined circuit-breaker and cable termination compartment

Functional description

In this application example, the arc flash sensor for zone 1.1 is connected to the I/O unit input number 1. If the arc flash sensor awakens and simultaneously VAMP 321 sends a current signal to the I/O unit, the zone 1.1 is isolated by the outgoing feeder breaker.

The arc flash sensor for zone 1.2 is connected to the I/O unit input number 2 or 3. If the arc flash sensor awakens and simultaneously VAMP 321 sends a current signal to the I/O unit, the zone 1.2 is isolated by the outgoing feeder breaker.

The arc flash sensors for zone 1 are connected to the I/O unit sensor channels 4...10. If a sensor awakens in zone 1, the light-only signal is transferred to VAMP 321 which then trips the main circuit breaker.

NOTICE For 12L and 12LD units, three sensor channels can trip independently their own zone, the other seven sensor channels can be allocated to another zone.

The sensor S2 connected to VAMP 321 in zone B overlaps the zone A. If the circuit breaker fails to isolate the failure in zone B, the sensor (S2) generates a time-delayed circuit-breaker failure protection trip to the upstream breaker.

The incoming feeder circuit breaker has a CBFP backup trip to the upstream breaker. If the zone 1 trip (T1) fails, the CBFP takes over and trips the upstream circuit breaker.

The zone A illustrates a typical medium voltage incoming feeder where the current transformers are located after the cable termination. In this case, an eventual arc flash fault in the cable termination does not activate the current element in VAMP 321. However, arc protection can be achieved by using the light-only principle. If an arc flash occurs in cable termination, the zone A is tripped by an upstream circuit breaker. The sensor S1 in zone A overlaps the incoming circuit breaker.

The zone A operates on light-only principle as the currents are not available for current and light operation.

The circuit-breaker failure protection (CBFP) protects in case there is a failure in zone 1, or in sensor S2 in zone B. The trip output (T2/CBFP) can function as a trip output, but also as a time-delayed circuit-breaker failure protection. To enable CBFP, an additional time-delayed stage needs to be created.

System components

- VAMP 321
- VAM 12LD I/O unit
- Seven VA1DA arc sensors
- VX001 modular cable for connecting the I/O unit to the IED

8.1.1. Connecting the devices

⚠WARNING Before connecting the devices, disconnect the supply voltage to the unit.

- Connect the arc sensors to the I/O unit's terminal block.
- Connect the I/O unit to the IED with a VX001 modular cable.
- Connect the arc sensors to the IED's terminal block.

8.1.2. Configuring VAM 12LD

⚠WARNING Before changing the programming switch positions, disconnect the supply voltage to the unit.

Each I/O unit connected to the communication bus has a unique address. Define the address by setting the I/O unit programming switches.
In this application example, the I/O unit operates for zone 1, and thereby the unit address is 0.

SW1 switch settings for the application example

Switch	Name	Setting	Description
1	L> ext/int	ON	ON = Arc stage activates on the light information provided by the unit's own sensors. OFF = Arc stage activates on light information received from any unit in the same protection zone.
2	Latch	ON	Determines the trip relay operation after an arc flash. ON = Trip relay remains engaged until the fault is acknowledged on the IED's local HMI. OFF = Trip relay operation follows the arc flash fault.
3	L/L+I	OFF	Determines the arc trip criteria. ON = Trip is based on light information only. OFF = Trip requires both light information and fault current.
4	Zone	OFF	Address weighting coefficient 16
5	Zone	OFF	Address weighting coefficient 8
6	Addr.	OFF	Address weighting coefficient 4
7	Addr.	OFF	Address weighting coefficient 2
8	Addr.	OFF	Address weighting coefficient 1

9. Connections

9.1. Rear panel

The device has a modular structure. The device is built from hardware modules, which are installed into 10 different slots at the back of the device. The location of the slots in shown in the following figure.

The type of hardware modules is defined by the ordering code. A mimum configuration is that there is a supply voltage card in slot 1 and an analog measurement card in slot 8.

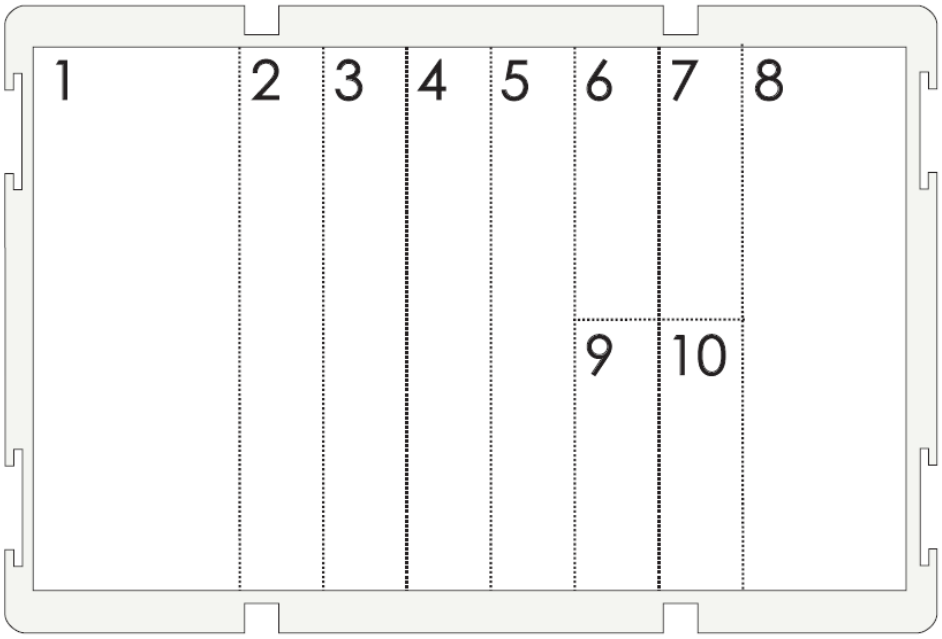


Figure 8.1.2-1 Slot numbering and card options in the VAMP 321 rear panel

Slot	Card
1	Supply voltage [V]
2	I/O card I (This slot is designed specially for Arc option card)
3...5	I/O cards II...IV for future use
6, 7	I/O option cards I and II for future use
8	Analog measurement card (I, U)
9, 10	Communication interface I and II for future use

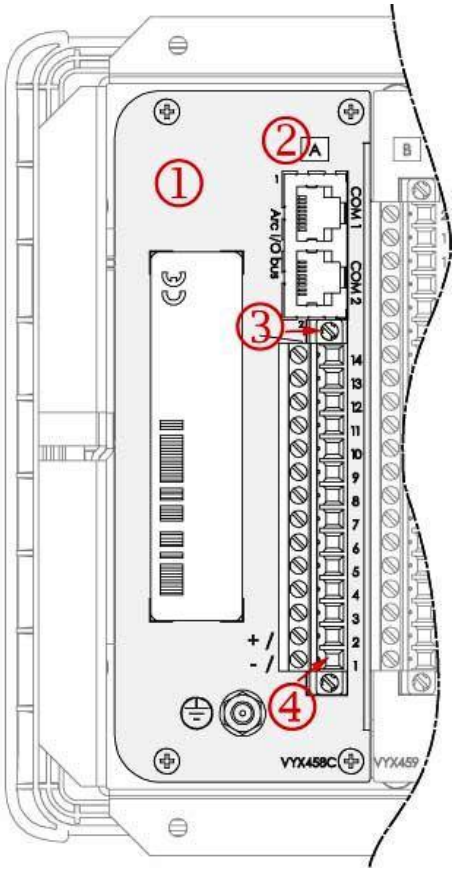


Figure 9.1-1 An example of defining the pin address 1/A/2:1

① Slot 1

② Card A

③ Connector 2

④ Pin 1

9.1.1. I/O cards and optional I/O cards

The configuration of the device can be checked from local HMI or VAMPSET menu called “Slot” or “SLOT INFO”. This contains “Card ID” which is the name of the card used by the device software.

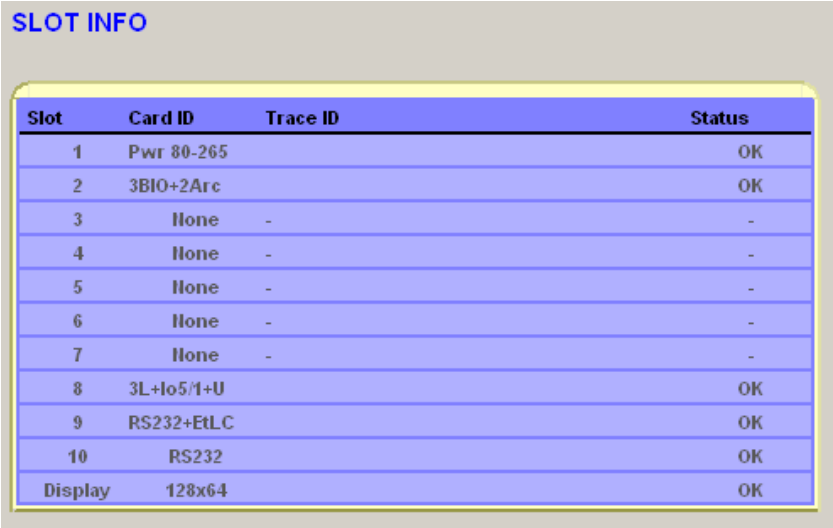


Figure 9.1.1-1 An example of showing the hardwaer configuraion by VAMPSET.

9.1.2. Supply voltage card "Pwr 80-265"

Pin No.	Symbol	Description
14	+24V	I/O unit operating voltage
13	GND	I/O unit ground potential
12	IF NO	Internal fault relay, normal open connector
11	IF NC	Internal fault relay, normal closed connector
10	IF COM	Internal fault relay, common connector
9	A1 NO	Alarm relay 1, normal open connector
8	A1 NC	Alarm relay 1, normal closed connector
7	A1 COM	Alarm relay 1, common connector
6	T1	Fast trip relay 1 for arc protection
5	T1	Fast trip relay 1 for arc protection
4	NC	No connection
3	NC	No connection
2	L / + / ~	Auxiliary voltage
1	N / - / ~	Auxiliary voltage

⚠WARNING Always connect the protective grounding before connecting the power supply.

9.1.3. I/O card "3BIO + 2Arc"

This card contains connections to 2 arc light sensors (e.g. VA1DA), 3 binary inputs, 3 binary outputs and 3 fast trip relays.

VAMP 321 terminal pins 2/B/1:1...20

Pin No.	Symbol	Description
20	T4	Fast trip relay 4 for arc protection
19	T4	Fast trip relay 4 for arc protection
18	T3	Fast trip relay 3 for arc protection
17	T3	Fast trip relay 3 for arc protection
16	T2	Fast trip relay 2 for arc protection
15	T2	Fast trip relay 2 for arc protection
14	BI3	Binary input 3
13	BI3	Binary input 3
12	BI2	Binary input 2
11	BI2	Binary input 2
10	BI1	Binary input 1
9	BI1	Binary input 1
8	BO COM	Binary output 1...3 common
7	BO3	Binary output 3
6	BO2	Binary output 2
5	BO1	Binary output 1
4	SEN2	Arc sensor channel 2
3	SEN2	Arc sensor channel 2
2	SEN1	Arc sensor channel 1
1	SEN1	Arc sensor channel 1

9.1.4. Analog measurement card "3L+Io5/1+U"

This card contains connections current measurement transformers for measuring of the phase currents L1…L3 and residual current Io, and one voltage measurement transformer for measuring of the Uo, ULL or ULN.

VAMP 321 terminal pins 8/A/1:1...11

Pin No.	Symbol	Description
1	IL1(S1)	Phase current L1 (S1)
2	IL1(S2)	Phase current L1 (S2)
3	IL2(S1)	Phase current L2 (S1)
4	IL2(S2)	Phase current L2 (S2)
5	IL3(S1)	Phase current L3 (S1)
6	IL3(S2)	Phase current L3 (S2)
7	Io1	Residual current Io1 common for 1A and 5A (S1)
8	Io1/5A	Residual current Io1 5A (S2)
9	Io1/1A	Residual current Io1 1A (S2)
10	Uo/ULL/ULN	Uo (da)/ ULL (a)/ ULN (a)
11	Uo/ULL/ULN	U0 (dn)/ ULL (b)/ ULN (n)

9.1.5. I/O option card "4xArc"

This card can contain connections to 4 arc light sensors (e.g. VA1DA). If the card is in slot 6 it provides sensors 3…6 and in slot sensors 7…10.

VAMP 321 4xArc option card terminals (slot 6)

Pin No.	Symbol	Description
8	Sen 6 -	Arc sensor 6 negative terminal
7	Sen 6 +	Arc sensor 6 positive terminal
6	Sen 5 -	Arc sensor 5 negative terminal
5	Sen 5 +	Arc sensor 5 positive terminal
4	Sen 4 -	Arc sensor 4 negative terminal
3	Sen 4 +	Arc sensor 4 positive terminal
2	Sen 3 -	Arc sensor 3 negative terminal
1	Sen 3 +	Arc sensor 3 positive terminal

VAMP 321 4xArc option card terminals (slot 7)

Pin No.	Symbol	Description
8	Sen 10 -	Arc sensor 10 negative terminal
7	Sen 10 +	Arc sensor 10 positive terminal
6	Sen 9 -	Arc sensor 9 negative terminal
5	Sen 9 +	Arc sensor 9 positive terminal
4	Sen 8 -	Arc sensor 8 negative terminal
3	Sen 8 +	Arc sensor 8 positive terminal
2	Sen 7 -	Arc sensor 7 negative terminal
1	Sen 7 +	Arc sensor 7 positive terminal

⚠WARNING Always connect the protective grounding before connecting the power supply.

9.1.6. I/O card "6DI+4DO"

This card provides 6 digital inputs and 4 relays outputs. The threshold level is selectable by the last digit of the ordering code.

Pin No.	Symbol	Description
20	T8	Trip relay T8
19		
18	T7	Trip relay T7
17		
16	T6	Trip relay T6
15		
14	T5	Trip relay T5
13		
12	DI 6	Digital input 6
11		
10	DI 5	Digital input 5
9		
8	DI 4	Digital input 4
7		
6	DI 3	Digital input 3
5		
4	DI 2	Digital input 2
3		
2	DI 1	Digital input 1
1		

9.1.7. I/O card "2xIGBT"

This card contains 2 semiconductor outputs.

Pin No.	Symbol	Description
19..20	NC	No Connection
18	IGBT2.2	IGBT output 2 terminal 2
17		
16	IGBT2.1	IGBT output 2 terminal 1
15		
8..14	NC	No Connection
7	IGBT1.2	IGBT output 1 terminal 2
6		
5	IGBT1.1	IGBT output 1 terminal 1
4		
1..3	NC	No Connection

9.2. Auxiliary voltage

The external auxiliary voltage U_{aux} (80…265 V ac or V dc, or optionally 24…48 V dc) for the device is connected to the terminals 1/A/2: 1-2.

NOTICE When optional 18…48 Vdc power module is used the polarity is as follows: 1/A/2:2 positive, 1/A/2:1 negative.

9.3. Communication connections

9.3.1. Front panel USB connector

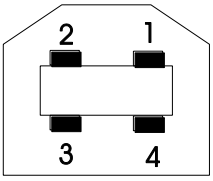


Figure 9.3.1-1 Pin numbering of the front panel USB type B connector

Pin	Signal name
1	VBUS
2	D-
3	D+
4	GND
Shell	Shield

9.3.2. COM 5 (Arc I/O Bus) connector

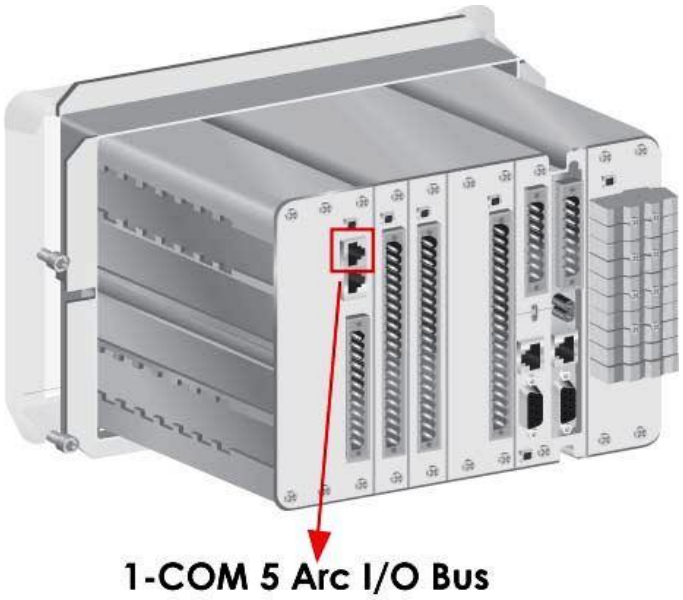
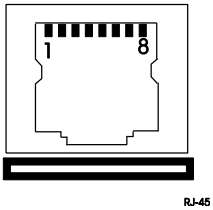


Figure 9.3.2-1 Arc I/O Bus connectors at the back of the device

Arc I/O Bus interface contain two identical RJ-45 connectors. The pin numbering is as follows:

RJ-45 connector  	1= Arc comm A 2= +24V 3= RS485 A 4= GND 5= GND 6= RS485 B 7= +24V 8= Arc comm B

9.3.3. Pin assignments of the optional communication interface cards

The device can be equipped with optional communication cards. The physical location of the card is slot 9 or 10 at the back of the device. The cards can be installed in the field (when power is first turned off).

There are four "logical communication ports" available in the device: COM 1, COM 2, COM 3, COM 4 and ETHERNET. Depending on the optional communication card type one or more of these ports are physically available at the external connectors.

The communication card types and their pin assignments are introduced in the following table.

Communication option modules and their pin numbering

Type	Order code, Name	Communication ports	Signal levels	Connectors	Pin usage
3VCM RS232	B = RS232	COM 1 / COM 2 COM 3 / COM 4 COM 1, 2 in slot 10. COM 3 , 4 in slot 9.	RS-232	D-connector	1 = TX COM2/COM 4 2 = TX COM1/COM3 3 = RX COM1/COM3 7 = GND 8 = TX COM2/COM4 9 = +12V
3VCM RS232+EtRJ	C = RS232 +Ethernet RJ-45	COM 1 / COM 2 COM 3 / COM 4 COM 1, 2 in slot 10. COM 3 , 4 in slot 9. ETHERNET	RS-232 Ethernet 100Mbps	D-connector RJ-45	1 = TX COM2/COM 4 2 = TX COM1/COM3 3 = RX COM1/COM3 7 = GND 8 = TX COM2/COM4 9 = +12V 1=Transmit+ 2=Transmit- 3=Receive+ 4=Reserved 5=Reserved 6=Receive- 7=Reserved 8=Reserved
3VCM RS232+EtLC	D = RS232 +Ethernet LC	COM 1 / COM 2 COM 3 / COM 4 COM 1, 2 in slot 10. COM 3 , 4 in slot 9. ETHERNET	RS-232 Light 100Mbps	D-connector LC-connector	1 = TX COM2/COM 4 2 = TX COM1/COM3 3 = RX COM1/COM3 7 = GND 8 = TX COM2/COM4 9 = +12V RX=Upper LC-connector TX=Lower LC-connector

NOTICE

When communication option module of type 3VCM RS232+XXXX is used in slot 9 then serial ports COM 3 and COM 4 are available and in slot 10 serial ports COM 1 and COM 2 are available.

9.4. Block diagrams

9.4.1. Functional block diagram

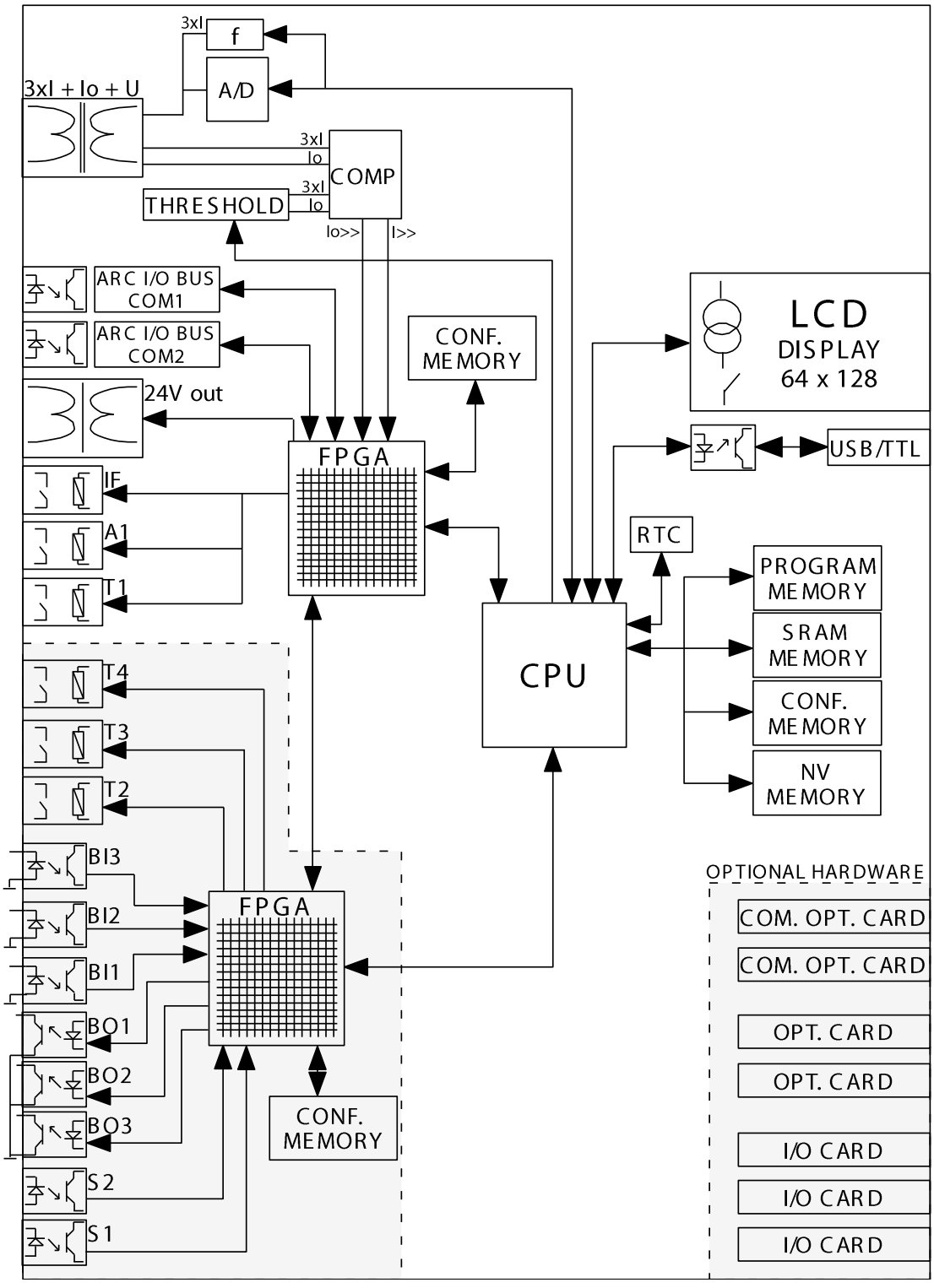


Figure 9.4.1-1 Functional block diagram for VAMP 321 AB AAA AAAAA A1

9.4.2. Block diagram of VAMP 321 ABAAA-AAAAA-A1/2/3

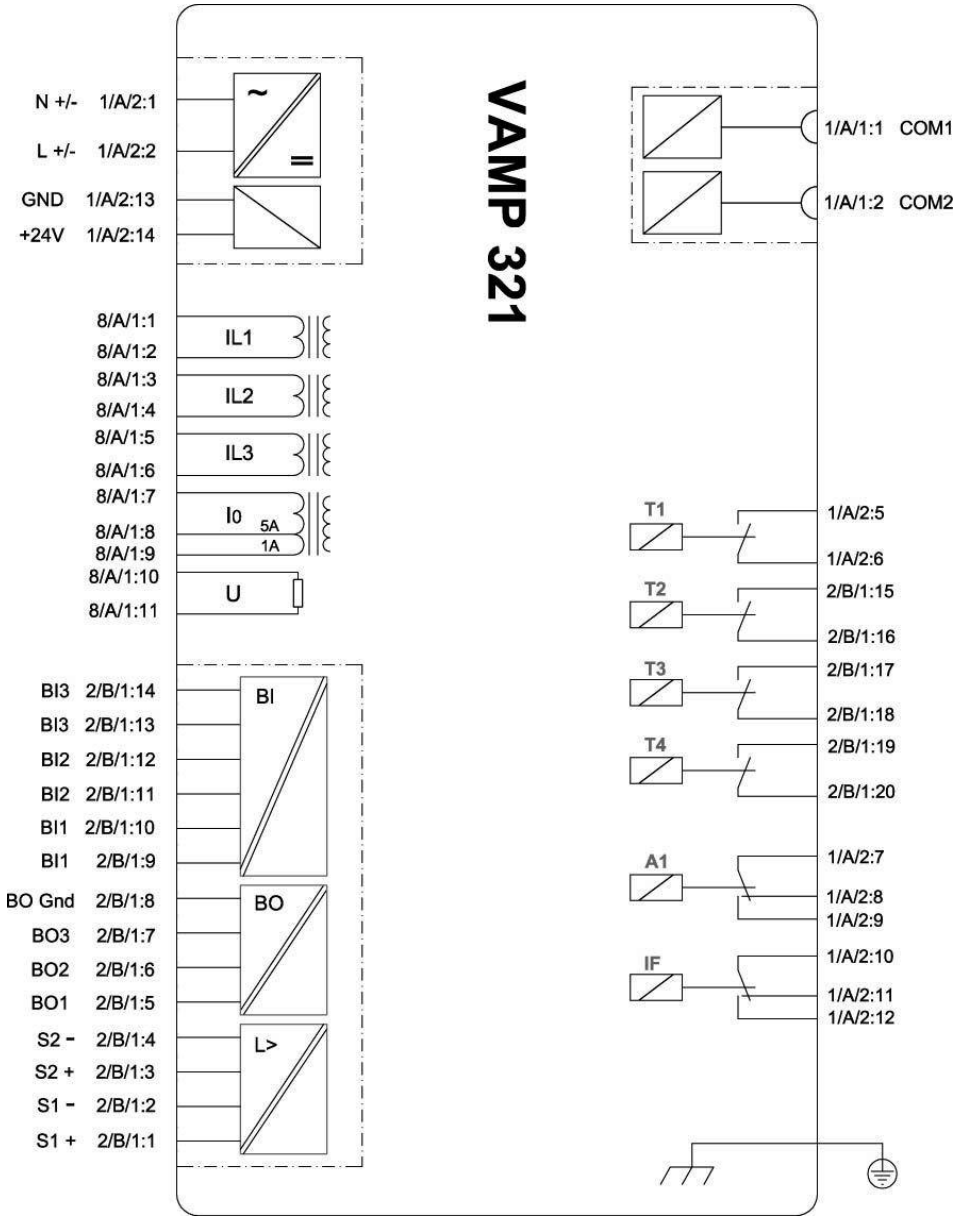


Figure 9.4.2-1 Block diagram of VAMP 321-ABAAA-AAAAA-A1/2/3

10. Technical data

10.1. VAMP 321

Auxiliary voltage

Us	110…240 V AC/DC, -/+ 10% 110/120/220/240 V ac 110/125/220 V dc
Power consumption (order code – ABAAA-AAAA-AA) Power consumption increases when more I/O cards or optional I/O or communication cards are used.	20 W (internal) 50 W (output 24 V DC)

Measuring circuits

Rated current I_N	5 A (configurable for CT secondaries 1 – 10 A)
- Current measuring range	0…250 A
- Thermal withstand	20 A (continuously) 100 A (for 10 s) 500 A (for 1 s)
- Burden	< 0.2 VA
Rated current I_0	5 A / 1 A (optionally 1 A / 0.2 A)
- Current measuring range	0…50 A / 10 A
- Thermal withstand	4 x I_0 (continuously) 20 x I_0 (for 10 s) 100 x I_0 (for 1 s)
- Burden	< 0.2 VA
Rated voltage U_N	100 V (configurable for VT secondaries 50 – 120 V)
- Voltage measuring range	0 - 175 V
- Continuous voltage withstand	250 V
- Burden	< 0.5 VA
Rated frequency f_N	45 - 65 Hz
Terminal block: - Solid or stranded wire	Maximum wire dimension: 4 mm² (10-12 AWG)

Trip contacts

Number of contacts	Depends on the ordering code.
Rated voltage	250 V ac/dc
Continuous carry	5 A
Make and carry, 0.5 s Make and carry, 3s	30 A 15 A
Breaking capacity, DC (L/R=40ms) at 48 V dc: at 110 V dc: at 220 V dc	 5 A 3 A 1 A
Contact material	AgNi 90/10
Terminal block: - Phoenix MVSTBW or equivalent	Maximum wire dimension: 2.5 mm² (13-14 AWG)

Alarm contacts

Number of contacts:	Depends on the ordering code.
Rated voltage	250 V ac/dc
Continuous carry	5 A
Breaking capacity, DC (L/R=40ms) at 48 V dc: at 110 V dc: at 220 V dc	 1,3 A 0,4 A 0,2 A
Contact material	AgNi 0.15 gold plated
Terminal block - Phoenix MVSTBW or equivalent	Maximum wire dimension 2.5 mm² (13-14 AWG)

BIO inputs/outputs

Rated output voltage	+30 V DC
Rated input voltage	+40 V DC (absolute max 250 V DC)
Rated current (BO)	20 mA
Rated current (BI)	5 mA
L> BI line (IN)	3 pcs
L> BO lines (OUT)	3 pcs

Arc I/O bus (RJ-45)

Multi drop	Max 16 I/O units and 3 main units
Supply to I/O units	Isolated 24 V DC
Arc RS485 communication (master-slave)	RS-485 information/self-supervision
Arc I/O communication	4 zone ARC and 1 zone OC line

Arc sensor inputs

Number of inputs	Depends on the ordering code
Supply to sensor	Isolated 12 V DC

10.2. VAM I/O units

TRIP contacts

Rated voltage	250 V AC/DC
Continuous carry	5 A
Make and carry for 0.5 s	30 A
Make and carry for 3 s	15 A
Operating time	<7 ms

Digital inputs

Rated voltage	24 V DC
Rated current	5 mA

Digital outputs

Rated voltage	24 V DC
Rated current	20 mA (max)

VAM 10L / 10LD / 12L / 12LD

	VAM 10L VAM 10LD	VAM 12L VAM 12LD
No. of trip contacts	1	3
No. of digital inputs	1	-
No. of digital outputs	1	-
No. of arc sensor channels	10	
Power supply	+24 V DC via modular cable or terminals	
Power consumption, In (stand-by)	45 mA	
Power consumption per activated channel I sensAct	20 mA	
Total power consumption	45 mA +(n x I sens Act) (n = Number of active sensors)	

VAM 4C / VAM 4CD

No. of trip contacts	1
No. of digital inputs	1
No. of digital outputs	1

Measuring circuits

Rated current I_N	1 A / 5 A
Rated frequency f_N	45...65 Hz
Power consumption	≤0.3 VA
Thermal withstand	60 x In for 1 s

Operating settings

Phase current stage IL>	0.5...6.0 x In
Earth-fault current Io>	0.05...5.0 x In
Accuracy	±5%
Reset ratio	0.95

10.3. VAMP 4R trip multiplier relay

Two groups

Power supply	24 V DC
Control signal	18..265 V AC/DC
Tripping contacts	4 pcs NO, 4 pcs NC
Rated voltage	250V AC/DC
Continuous carry	5 A
Make and carry for 0.5s	30 A
Make and carry for 3s	15 A
Contact material	AgNi

11. Tests and environmental conditions

IEC 60255

- Clause 7 (Verification of the accuracy)
- Clauses 4.2 and 4.3 are covered by IEC 60255-27

IEC 60255-26

- IEC 60255-11 (Voltage variations and interruptions)
- IEC 60255-22-1 (1 MHz burst)
- IEC 60255-22-2 class 4 (ESD)
- IEC 60255-22-3 (Radiated EM field immunity)
- IEC 60255-22-4 class A (EFT)
- IEC 60255-22-5 class 4 (Surge)
- IEC 60255-22-6 (Conducted disturbances immunity)
- IEC 60255-22-7 (Power frequency disturbance immunity)
- IEC 60255-25 (Radiated and conducted emission)

IEC 60255-27

- IEC 60068-2-2 (Dry heat test)
- IEC 60068-2-1 (Cold test)
- IEC 60068-2-78 (Damp heat)
- IEC 60068-2-30 (Damp heat)
- IEC 60255-21-1 (Vibration)
- IEC 60255-21-2 (Shock and bump)
- IEC 60255-5 (Insulation voltage test)
- IEC 60259 (IP class rating)
- Chapter 10.5.2.2 Clearances and creepage distances
- Chapter 10.5.4.2 Flammability of insulating materials, components and fire enclosure
- Chapter 10.5.4.3 Thermal short-time test (Voltage and current transformers)
- Chapter 10.5.4.4 Output relay, make and carry
- Chapter 10.5.4.5 Single-fault condition

EN 50263 (EMC directive), EN 61000-6-4, EN 61000-6-2

- EN 55011 (Emission levels and radiation immunity for ISM devices)
- EN 60255-22-2 (ESD)
- EN 61000-4-2 (ESD)
- EN 61000-4-3 (Radiated disturbances)
- EN 61000-4-4 (EFT)
- EN 61000-4-5 (Surge)
- EN 61000-4-6 (Conducted disturbances)
- EN 61000-4-8 (Power frequency magnetic field)
- IEC 60255-11 (Ripple in DC)
- IEC 60255-22-1 (1 MHz burst)
- IEC 60255-22-3 (Radiated immunity)
- IEC 60255-22-4 (EFT)
- IEC 60255-22-6 (Conducted disturbances)
- IEC 60255-5 (LVD directive)

Environmental conditions

Operating temperature	-25…+60°C
Relative humidity	< 95%, no condensation allowed
Degree of protection (IEC 60529)	IP54
Weight	4.0 kg
Dimension (w x h x d)	270 x 176 x 230 mm

12. Mounting

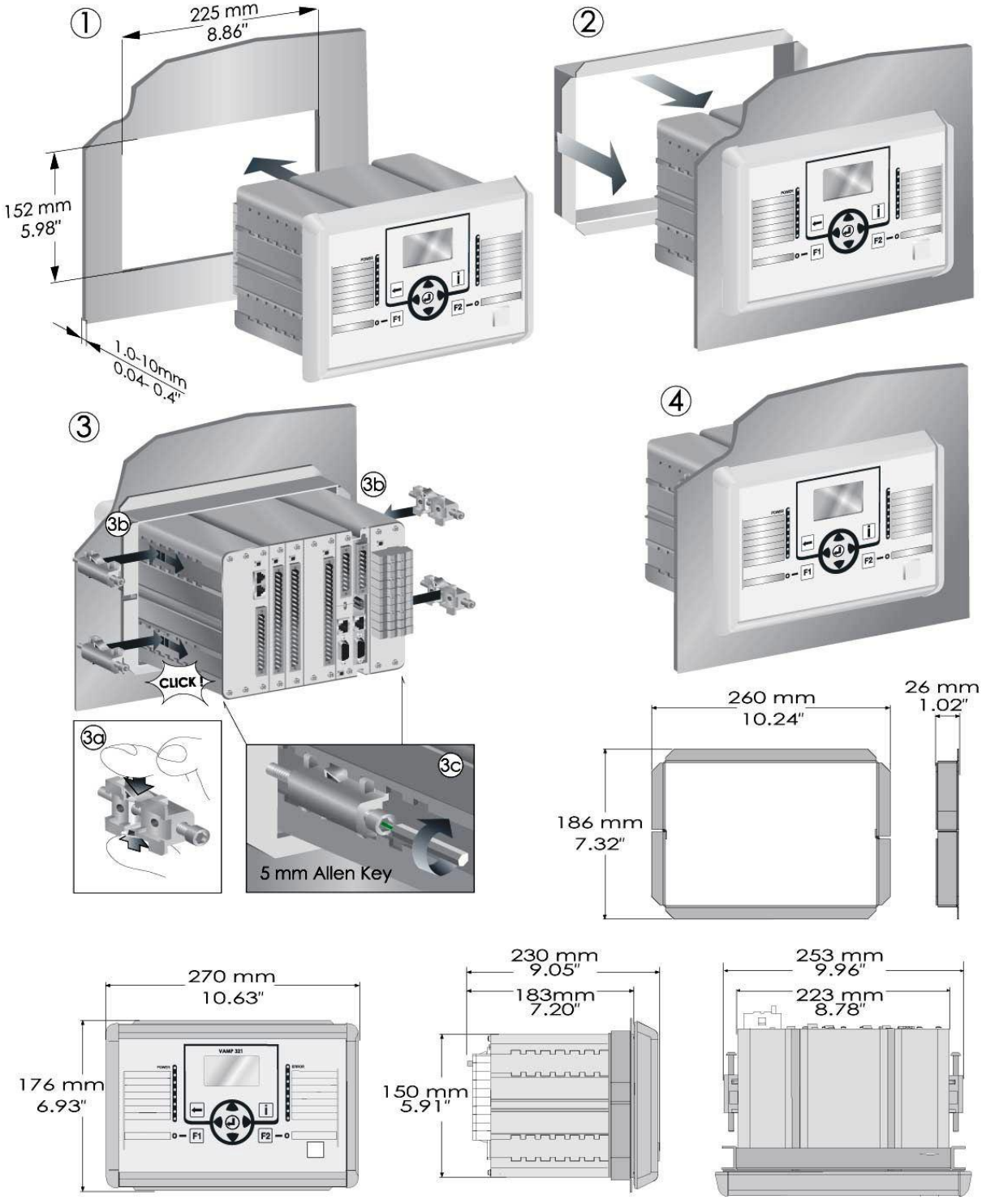
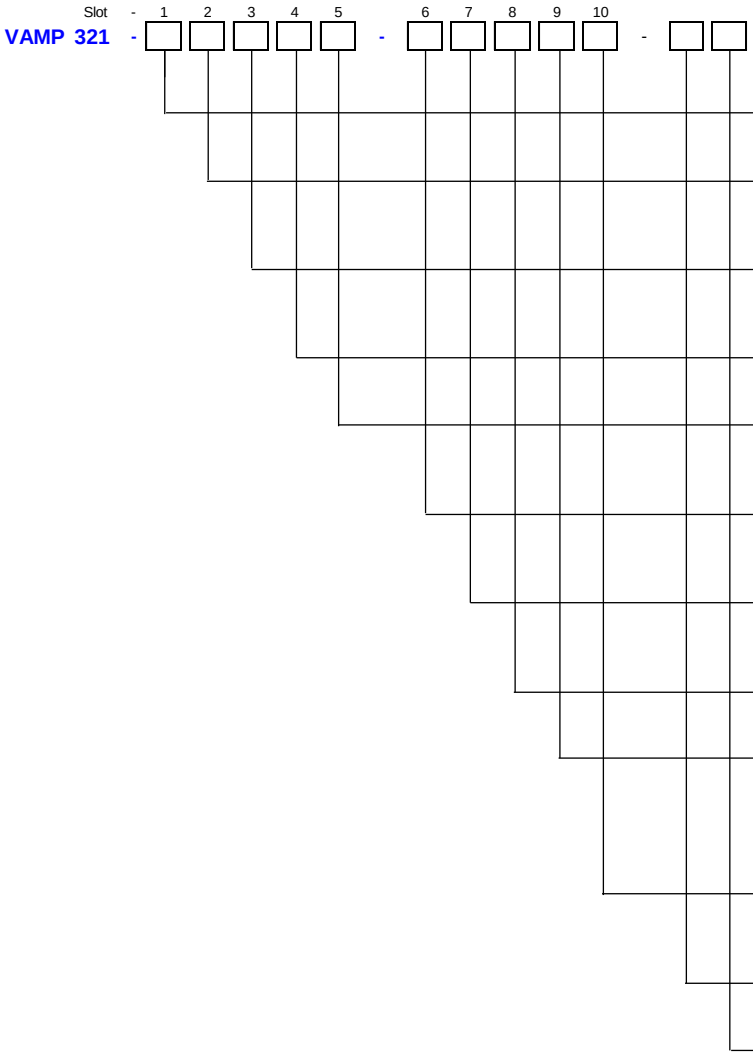


Figure 12-1 VAMP 321 mounting and dimensions

NOTICE See the mounting and commissioning instructions for more information.

13. Order information

VAMP 321 ORDERING CODE



Supply voltage [V]
A = 80 .. 265Vac/dc

I/O Card I
A = None
B = 3 x BI/BO, 2 x Arc sensor, T2, T3, T4

I/O Card II
A = None
B = Digital I/O; 6 x DI, 4 x DO

I/O Card III
A = None

I/O Card IV
A = None
D = 2 x IGBT High speed outputs (Excludes I/O Card slot III

I/O Option card I
A = None
D = 4 x Arc sensor

I/O Option card II
A = None
D = 4 x Arc sensor

Analog measurement card [A, V]
A = 3L + Io (5A / 1A) + U

Communication interface I
A = None
B = RS232
C = RS232 + Ethernet RJ-45
D = RS232 + Ethernet LC

Communication interface II
A = None
B = RS232

Display type
A = 128 x 64 LCD matrix

DI treshold voltage
1 = 24 VDC / 110 VAC
2 = 110 VDC / 220 VAC
3 = 220 VDC

Accessories :

Order Code	Explanation	Note
VAM 3L	Fiber sensor I/O unit (VAMP221 & 321)	3 fiber loops, 1 trip relay
VAM 3LX	Fiber sensor I/O unit (VAMP221 & 321)	3 fiber loops, 1 trip relay, adjustable sensitivity
VAM 4C	Current I/O unit (VAMP221 & 321)	3 current inputs, 1 trip relay
VAM 4CD	Current I/O unit (VAMP221 & 321)	3 current inputs, 1 trip relay, flush mounting
VAM 10L	Point sensor I/O unit (VAMP221 & 321)	10 sensor inputs, 1 trip relay
VAM 10LD	Point sensor I/O unit (VAMP221 & 321)	10 sensor inputs, 1 trip relay, flush mounting
VAM 12L	Point sensor I/O unit (VAMP221 &321)	10 sensor inputs, 3 trip relays
VAM 12LD	Point sensor I/O unit (VAMP221 & 321)	10 sensor inputs, 3 trip relays, flush mounting
VAMP 4R	Trip multiplier relay	4 x NO, 4 x NC, 2 groups
VA 1 DA-6	Arc Sensor	Cable length 6m
VA 1 DA-20	Arc Sensor	Cable length 20m
VA 1 DT-6	Temperature Sensor	Cable length 6m
VA 1 DP-5	Portable Arc Sensor	Cable length 5m
VA 1 DP-5D	Portable Arc Sensor	Cable lenght 5m
VA 1 EH-6	Arc Sensor (Pipe type)	Cable length 6m
VA 1 EH-20	Arc Sensor (Pipe type)	Cable length 20m
ARC SLm-x	Fiber sensor, 8 000 lx	x = fiber lenght (2
VX001-xx	Modular Cable VAM <-> VAM (xx = Cable length [m])	Preferred Cable Lenghts (3
VX031-5	Extension cable for VA1DP-5D	Cable lenght 5m
VX052-3	USB programming cable (Vampset)	Cable length 3m
VX054-3	Interface cable to VPA 3 CG (Profibus module) for RS 232	Cable length 3m
VYX001	Surface Mounting Plate for Sensors	Z-shaped
VYX002	Surface Mounting Plate for Sensors	L-shaped
VSE001	Fiber optic Interface Module	RS-232 mode only
VSE002	RS485 Interface Module	RS-232 mode only
VPA3CG	Profibus interface module	

Note 2. Fibre lengths 1, 5, 10, 15, 20, 25, 30, 35, 40, 50 or 70 m

Note 3. Cable lengths 1, 3, 5, 7, 10, 15, 20, 25 & 30

14. Version history

Manual history

Document revision	Changes
VM321.EN001	First revision.

Firmware history

Firmware version	Changes
10.85	First version.
10.89	Support for IEC 61850
10.102	Support for “2xIGBT” card and “6DI/4DO” card

15. Glossary

Term	Description
Document file	Stores information about the IED settings, events and fault logs.
FPGA	Field-programmable gate array
HMI	Human-machine interface
IED	Intelligent electronic device
LCD	Liquid crystal display
LED	Light-emitting diode
Local HMI	IED front panel with display and push-buttons
PC	Personal computer
VAMPSET	Configuration tool for VAMP protection devices

We reserve the right to changes without prior notice

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